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EFFECT OF GEOGRAPHICAL VARIATION ON PERFORMANCE OF RECIRCULATING COOLING PONDS

Edward L. Thackston

Vanderbilt University

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16. Abstract

The energy budget approach to cooling ponds has been outlined and applied to closed cycle, recirculating cooling ponds. Monthly average weather data from 88 stations throughout the U.S. were used to calculate equilibrium temperatures, heat exchange coefficients, and the average temperature of various sized ponds receiving the effluent from a standard power plant of 1000-mw capacity, both for average and extreme weather conditions. The data for each station is shown on a separate chart, and the variation of these results across the U.S. is depicted by a series of 38 maps of the U.S., with contours connecting equal values of the parameters. The results may also be used to estimate cooling pond performance for other sized power plants and other sized ponds.

The maps disclose variations across the U.S., on a given date, of up to 55°F in equilibrium temperature, up to 100% difference in heat exchange coefficients, and up to 50°F difference in pond temperatures. Increase of pond temperature over equilibrium is greater in winter than in summer.

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EFFECT OF GEOGRAPHICAL VARIATION ON PERFORMANCE OF RECIRCULATING COOLING PONDS

By

Edward L. Thackston

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INTRODUCTION

The use of recirculating ponds for cooling heated condenser water before reuse at large electric generating stations will probably be much more common in the future than it is now. Stricter water quality standards, increased pressure from state and federal regulatory agencies and the public, greater amounts of heat to be dissipated at a single location because of larger modern generating stations, are all combining to make this trend inevitable.

Heated condenser water may be cooled for reuse by dry cooling towers, wet cooling towers, or cooling ponds. The dry cooling tower depends almost solely on conduction for heat dissipation, and the wet cooling tower depends almost solely on evaporation. Both involve high capital costs, although wet cooling towers are considerably cheaper than dry towers.

Cooling ponds dissipate heat by radiation, evaporation, and conduction. By relying less heavily on evaporation, they do not consume as much water as towers for the dissipation of the excess heat. However, by not having a forced draft, either structurally or mechanically induced, they require much greater areas. In localities where sufficient area is available, cooling ponds frequently are the cheapest and simplest method for cooling water before reuse or discharge to a receiving stream.

The question of whether the effluent from a cooling pond should be reused or discharged to the stream from which it came is a complex question involving such things as availability of sufficient water, temperature rise (and fall) standards, mixing zones, pumping heads and arrangements, salt buildup in recirculating ponds, and the differences in plant efficiency when using water at the pond temperature as compared to the efficiency when using water directly from a stream at what will usually be a lower temperature. In many locations, sufficient water is simply not available to allow discharge of the pond effluent back to the stream. In these cases, recirculating ponds must be used.

Even when sufficient water may be available, the factors listed above, along with other local factors, generally dictate that cooling ponds at large generating stations be of the recirculating type. The decision may be to accept the slightly higher intake temperatures and lower plant efficiency rather than to be forced to gamble on consistently varying conditions of stream flow, stream temperature, and meteorological conditions.

The design of cooling ponds is sometimes based on rules of thumb, such as 1 to 2 acres per megawatt of installed capacity, or 75 to 150 BTU of heat loss per hour per square foot coupled with engineering judgment and experience. However, rational design should be based on the total energy budget, since regional or local meteorological conditions can greatly influence the rate of heat transfer, and, thus, the size of ponds necessary to produce a given cooling effect.

Many references are available in the literature on the energy budget approach to heat transfer calculations, and some give illustrative examples. However, none provide the engineer with a quick estimate of pond size and performance for a specific location necessary to make preliminary feasibility determinations, or to check the reasonableness of calculations. This is the purpose of the present investigation. Calculated energy budget data will be presented for sites representing the entire contiguous United States.

A consultant or a power company may use this data to determine approximate pond sizes necessary to produce a specified cooling effect or plant intake temperature at a given site; to investigate the effect on pond size of different cooling requirements; to determine the influence of season on pond performance; to estimate the effect of different geometrical configurations; and to estimate the effect of possible alternate sites.

The engineer for a regulatory agency can use this data as an independent check on the reasonableness and/or adequacy of proposed designs which he is charged with reviewing, by determining or estimating the same parameters of performance.

This report is similar to an earlier report (1) which presented data and results on once-through cooling ponds, i.e., ponds used to cool heated condenser water before discharge back to the stream. Some of the text of this report, especially the background material on the heat budget and methods of calculation and the tabulation of meteorological variables used, are identical to that contained in the earlier report. In addition, the top halves of the figures presenting results from individual weather stations on the variation of equilibrium temperature and heat exchange coefficient throughout the year are identical to those in the earlier report. This arrangement is considered necessary in order that this report may be complete within itself and not depend on the earlier report for explanation of the results contained in this report.

DATA TO BE PRESENTED

In the design of a recirculating cooling pond, the critical dependent variable, and the usual basis of comparison of all alternatives, is cost. However, the total cost involves many factors, such as plant efficiency changes with changing condenser water intake temperature, land costs, pumping costs, and many others. Since the object of this report is to study and report on the effects of geographical variation only, as embodied in the local meteorological conditions, comparisons must be made for a given situation, i.e., a given heat load or "standard plant." The "standard plant" selected will be described below.

For a given plant and given cost factors, the key dependent variable from an engineering standpoint is the pond temperature or plant intake temperature. This will be a function of pond size (bringing in the land cost factor) and will influence the plant efficiency (thus bringing in the power cost factor). In addition to pond size, the plant intake temperature will be a function of pond shape, season of the year, geographical location, and variation of meteorological variables at a given site.

For comparative purposes, a completely mixed pond will be used, and the pond temperature will be calculated for each month of the year at each of 88 sites, for three different sizes of ponds, and for both "normal" (average) meteorological conditions and "extreme" heating conditions (those meteorological conditions conducive to excess heating which occur with some predetermined critical frequency).

In order to help explain the pattern of variation of pond temperatures throughout the year and across the country, and in order to present data which can be used to estimate cooling pond performance and requirements for ponds serving plants different from the standard plant, two other parameters were calculated for each month at each site for both normal and extreme meteorological conditions. These were the equilibrium temperature and the heat exchange coefficient, which are also explained below.

The Standard Plant

The standard plant assumed for all calculations was of 1000-megawatt capacity. The flow of cooling water was 1350 cfs, and the temperature rise across the condensers was 15°F. This is equivalent to a plant efficiency of 37 to 38 percent. The exact efficiency, given these parameters, would be a function of the thermodynamic efficiency and the amount of heat lost through the walls of the boilers, through the stack, etc. The heat rejection rate in the condenser cooling water from the standard plant was thus 6.06×10^9 BTU/hr, or 1.46×10^{11} BTU/day.

Equilibrium Temperature

The equilibrium temperature is the temperature to which a body of water would eventually come if exposed to constant meteorological conditions. It is, therefore, a function of the particular conditions at a given location. A body of water not at the equilibrium temperature will tend to approach equilibrium asymptotically. The equilibrium temperature will vary throughout the day and throughout the year as the solar radiation, air temperature, wind speed, and other meteorological variables vary. A very shallow body of water will vary widely in temperature during the day as it follows the changing equilibrium temperature. However, the heat content of water is so great that the temperature of large, deep bodies of water does not fluctuate greatly during the day. Thus, average daily conditions are reasonably descriptive for large bodies of water, and the equilibrium temperature may be calculated on an average daily basis.

The temperature of natural water bodies continually approaches the equilibrium temperature but lags behind any changes. It is usually very close to equilibrium during the summer and winter, but is lower during the spring as the equilibrium temperature rises rapidly, and higher during the fall as the equilibrium temperature falls rapidly.

Surface Heat Exchange Coefficient

An isolated body of water not at equilibrium will approach equilibrium at a rate approximately proportional to the difference between actual surface temperature and equilibrium temperature (the forcing function), and to a rate constant which is a function of meteorological conditions (the heat exchange coefficient). This can be expressed as

$$\frac{\partial H}{\partial t} = - K(T_w - T_e) \tag{1}$$

where H = enthalpy, BTU's,
t = time, days,
K = surface heat exchange coefficient, BTU/ft^2-day-°F,
T_w = water surface temperature, °F,
T_e = equilibrium temperature, °F.

Equation 1 is not an exact description of the process (even if K is a constant), because all of the heat exchange processes are not truly linear functions of temperature, but it is close enough to be descriptive of relative magnitudes and trends. Comparison of the heat exchange coefficient calculated for various seasons, locations, and frequencies of occurrence will provide insight into the relative efficiency of cooling ponds under different conditions.

Pond Temperature at Standard Plant

Equation 1 may be used to calculate rates of surface heat exchange for given time increments (after calculating K and T_e from average meteorological conditions for that time increment) and applied to the water volume to compute the temperature change. This approach to computing water temperatures was developed by Duttweiler (2) and has been used extensively by Edinger, et al. (3,4,5). Because of its mathematical simplicity, it is the preferred approach to be used in many situations of complex geometry and hydraulics.

Another approach is to compute the heat transfer during a given time increment due to each mechanism of heat exchange and sum them to obtain the total heat gain or loss. An example of this approach is given by Raphael (6). This calculation approach is more accurate, because the individual expressions for heat transfer do not need to be linearized, but its mathematical complexity limits its application to simple hydraulic configurations, such as plug flow or backmix flow in ponds or reservoirs, or one-dimensional flow in streams.

Since the object of this work is to compare the influence of location on cooling pond performance, a standard pond configuration will be assumed. This standard configuration should be as simple as possible, in order to facilitate comparison of conditions. Therefore, a completely mixed pond was assumed. Most one-cell ponds approach this condition in practice. For this simple configuration, Raphael's approach (6), calculating each individual energy transfer component, can be easily used. In addition, this approach allows one to tabulate the heat transfer due to different mechanisms under different conditions, and thereby to determine the effect of meteorological conditions on the individual mechanisms.

METHODS OF CALCULATION

Heat Budget

The net, or total surface heat exchange, H_t, of a body of water is

$$H_t = H_s + H_a + H_b + H_e + H_c \qquad (2)$$

where H_s is the absorbed solar radiation, H_a is the absorbed longwave atmospheric radiation, H_b is the longwave back radiation of the water body to space, H_e is the heat lost by evaporation, and H_c is the heat gained or lost by conduction. The individual terms will be defined so that they are positive when heat is being gained by the water body and negative when heat is being lost by the water body. Since all the signs in Equation 2 are positive, the same convention will hold for the net surface heat exchange, H_t.

Calculation of individual components of the heat budget generally followed the procedures outlined by Raphael (6). Much of his methodology was, in turn, derived from the Lake Hefner Studies of the U. S. Geological Survey reported by Anderson (7). Certain modifications to Raphael's procedure had to be made, however, to adapt it to machine computation. The calculation procedure was designed to require only the standard information tabulated by the weather bureau - temperature, relative humidity, wind speed, and cloud cover, plus the location of the site and the time of year.

Solar Radiation - Several tabulations or graphs of average daily solar radiation as a function of latitude and time of year are available (8,9, 10). Differences among them are generally in the order of 5 percent, but may be as much as 20 percent of the low values experienced in December and January. All three of these references give only average daily incident radiation. Absorbed radiation, however, is incident radiation minus reflected radiation. There is no simple way to calculate the reflected radiation from these data, because the fraction reflected is a function of solar altitude, which varies throughout the day. The average solar altitude varies throughout the year, and the reflectivity is not a linear function of solar altitude.

The use of Raphael's calculation procedure allows reflected radiation to be calculated easily, and a set of tables or curves similar to those in the references above can be constructed, but for actual absorbed radiation, not just incident radiation. It also will allow separation of direct and diffuse solar radiation for those situations where shading of part of the water surface is significant. Furthermore, the use of Raphael's procedure will allow calculation of radiation variation during the day.

The altitude of the sun above the horizon was calculated from the equation

$$\sin \alpha = \sin \phi \sin \delta + \cos \phi \cos \delta \cos h \qquad (3)$$

where α is the solar altitude, ϕ is the latitude of the site, δ is the declination of the sun, and h is the hour angle of the sun, which is positive before noon and negative after noon.

An equation for δ was fitted to data from a current solar ephemeris by a non-linear least squares method derived by Marquardt (11). Thackston,

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et al. (12), outlined its use in hydraulic and environmental engineering problems. The equation is

$$\delta = -23.28 \cos[(2\pi \text{day}/365) + 0.164] \qquad (4)$$

where day is the day of the year.

Raphael tabulated the total radiation (direct solar radiation plus diffuse, or sky, radiation) on a horizontal surface as a function of solar altitude, taken from the tables prepared by Moon (13) from U. S. Weather Bureau data.

Reflected solar radiation is a function of solar altitude, being greatest at the low altitudes. It is also a function of sky condition, being greater for clear skies than for overcast skies at low solar altitudes, and the reverse at high solar altitudes. However, the differences are negligible except at low solar altitudes, where the total radiation is very small anyway, and at high solar altitudes, which are rarely reached in the U.S. Therefore, the curve of average reflectivity as a function of solar altitude was applied to the total radiation tabulated by Raphael to obtain the net absorbed radiation as a function of solar altitude. A simple polynomial was fitted to the data by nonlinear least squares methods to produce the equation

$$H_o = 2.044\alpha + 0.1296\alpha^2 - 0.0019\alpha^3 + 0.0000076\alpha^4 \qquad (5)$$

where H_o is the absorbed solar radiation for clear sky in BTU per square foot per hour. The standard error of this equation was 2.01. The fit of the equation to the data is shown in Figure 1. The absorbed solar radiation for other sky conditions was calculated from the equation

$$H_s = (1 - 0.0071\ C^2)H_o \qquad (6)$$

where H_s is the actual absorbed solar radiation, and C is the cloud cover, in tenths of sky.

The procedure described above will calculate only the instantaneous radiation at a particular time. The instantaneous radiation may be assumed to represent the average radiation over a given time increment, but above an increment of three or four hours, the accuracy is unacceptable, due to the cyclic variation of radiation throughout the day. For longer averaging periods, a different procedure is required. Since this project used the day as the working time period, values of total daily radiation were computed for every tenth day of the year for every degree of latitude from 25° to 46°. The radiation intensity was computed by the procedure outlined above for every six minutes throughout the day and the total daily radiation was obtained by numerical integration. The total was divided by 24 to obtain average daily radiation values in BTU per square foot per hour. For each latitude, an equation was fitted to the calculated values by non-linear least squares procedures. The resulting equations are tabulated in Table 1. An example of the fit of three of the equations to the calculated data is shown in Figure 2. The equations were all inserted into the computer program for the heat budget, along with a procedure to select the equation for the latitude closest to the latitude of the site. The program also included provisions for calculating the instantaneous solar radiation, if conditions at a particular hour are desired.

The values of absorbed solar radiation calculated by this method are, of

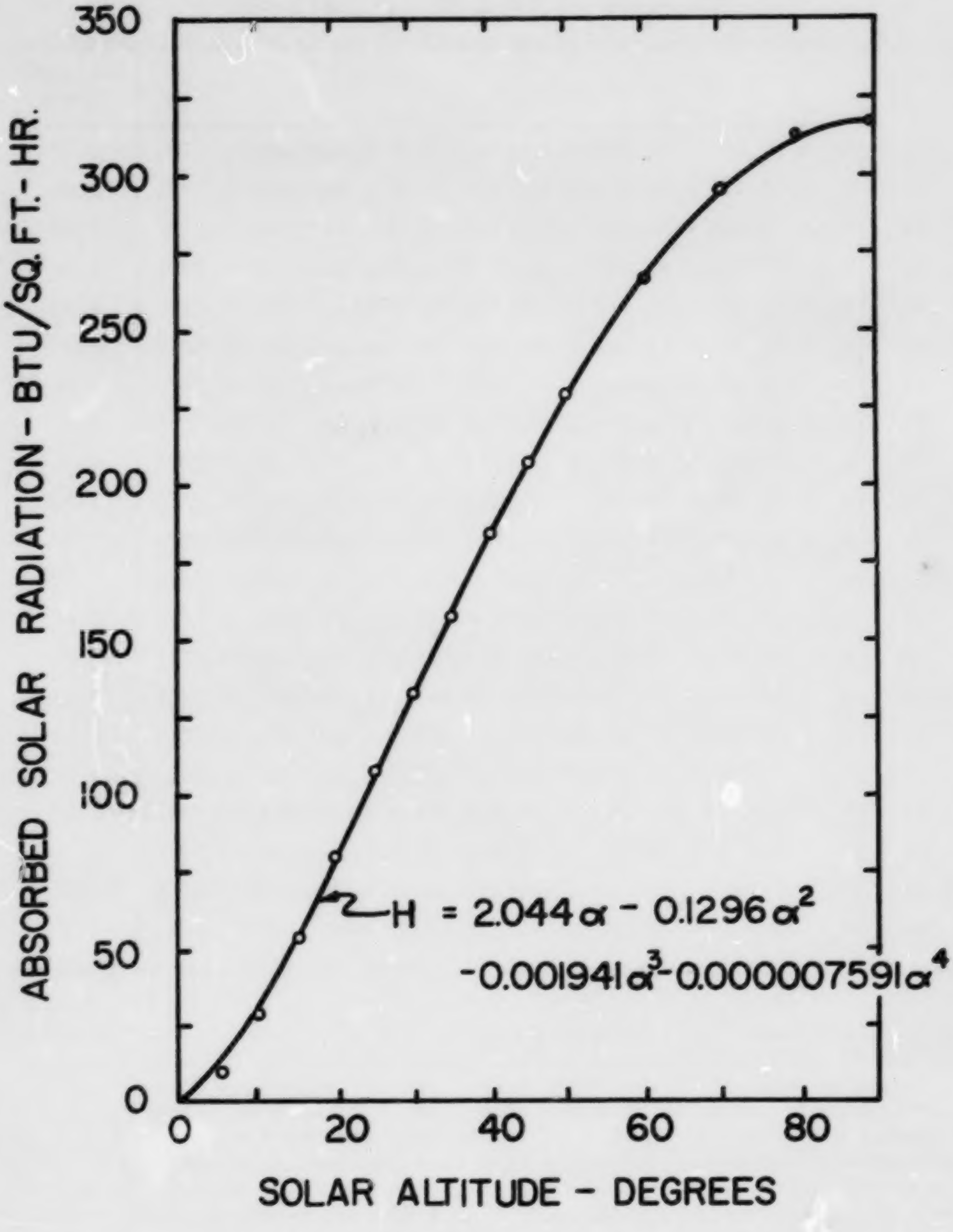


FIGURE 1 - ABSORBED SOLAR RADIATION AS A FUNCTION OF SOLAR ALTITUDE FOR CLEAR SKY CONDITIONS

TABLE 1 - EQUATIONS FOR AVERAGE DAILY ABSORBED SOLAR RADIATION (BTU/sq ft-hr) FOR CLEAR SKY CONDITIONS

Latitude	Equation	Standard Error
26	H_o = 80.155 - 29.207 x sin[2x3.14159 x day/366.+1.679]	2.76
27	H_o = 79.371 - 30.236 x sin[2x3.14159 x day/366.+1.713]	2.40
28	H_o = 78.566 - 31.219 x sin[2x3.14159 x day/366.+1.710]	2.33
29	H_o = 77.604 - 32.145 x sin[2x3.14159 x day/366.+1.740]	2.10
30	H_o = 76.655 - 33.156 x sin[2x3.14159 x day/366.+1.728]	2.02
31	H_o = 76.041 - 34.133 x sin[2x3.14159 x day/366.+1.694]	2.21
32	H_o = 75.060 - 35.194 x sin[2x3.14159 x day/366.+1.737]	1.85
33	H_o = 74.046 - 35.938 x sin[2x3.14159 x day/366.+1.734]	1.61
34	H_o = 73.161 - 36.834 x sin[2x3.14159 x day/366.+1.727]	1.52
35	H_o = 72.248 - 37.699 x sin[2x3.14159 x day/366.+1.738]	1.32
36	H_o = 71.390 - 38.598 x sin[2x3.14159 x day/366.+1.721]	1.32
37	H_o = 70.394 - 39.413 x sin[2x3.14159 x day/366.+1.730]	1.07
38	H_o = 69.350 - 40.188 x sin[2x3.14159 x day/366.+1.741]	0.86
39	H_o = 68.362 - 40.982 x sin[2x3.14159 x day/366.+1.739]	0.73
40	H_o = 67.281 - 41.706 x sin[2x3.14159 x day/366.+1.742]	0.61
41	H_o = 66.240 - 42.442 x sin[2x3.14159 x day/366.+1.736]	0.58
42	H_o = 65.197 - 43.128 x sin[2x3.14159 x day/366.+1.740]	0.54
43	H_o = 64.113 - 43.788 x sin[2x3.14159 x day/366.+1.739]	0.63
44	H_o = 63.010 - 44.471 x sin[2x3.14159 x day/366.+1.739]	0.76
45	H_o = 61.911 - 45.020 x sin[2x3.14159 x day/366.+1.740]	0.93
46	H_o = 60.782 - 45.639 x sin[2x3.14159 x day/366.+1.735]	1.16

course, less than the values of incident radiation given by references 8, 9, and 10. If an approximate reflectivity coefficient (between 5 and 10 percent) is applied to the other data, however, approximate comparisons can be made. Following this procedure, it is found that Koberg's (8) curves produce values about 5 BTU/sq ft-hour greater than these data throughout the year. Langhaar's (10) data substantially agrees with or is very slightly greater than Koberg's. The curves of Harmon, Weiss, and Wilson (9) produce values that are 5 to 8 BTU/sq ft-hour greater than this data during the winter, but up to 3 BTU/sq ft-hour lower during the summer. There is substantial agreement during the spring and fall. These differences are within the range of accuracy of the measurement devices used to record solar radiation and probably reflect the different measurement

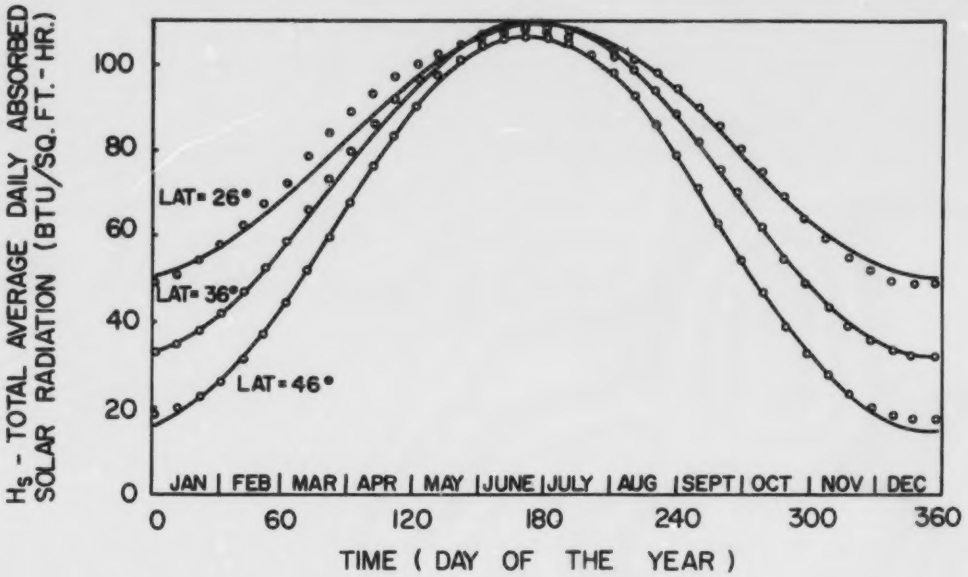


FIGURE 2 - AVERAGE DAILY ABSORBED RADIATION
FOR CLEAR SKY CONDITIONS AS A FUNCTION OF DAY OF YEAR

approaches and instrumentation used by different workers.

Atmospheric Radiation - Longwave atmospheric radiation is a function of many variables, including the distribution of temperature, moisture, carbon dioxide, ozone and other constituents throughout the entire air column over a site. However, since not all these data are normally available, Anderson (1954) proposed the following empirical relationship:

$$H_a = \sigma\beta(T_a + 460)^4 (1 - \omega) \tag{7}$$

in which H_a is the longwave atmospheric radiation in BTU/square foot per hour; σ is the Stephan-Boltzmann constant = 1.714×10^{-9} BTU/hr-sq ft-deg^4; β is a constant which is a function of the height and type of cloud cover and the atmospheric vapor pressure, e_a, in inches of Hg; T_a is the air temperature, in degrees Rankine; and ω is the reflectivity of the water surface, usually taken as 0.03. Raphael converted Anderson's figures and data to a single graph of β vs. e_a, with straight lines representing various values of cloud cover.

This graph was adapted for machine computation by writing an equation of the form

$$\beta = a + b\ e_a \tag{8}$$

where a and b are constants, for each value of cloud cover, and instructing the computer to pick the correct equation, based on the value of cloud cover read as data. The eleven equations used are tabulated in Table 2.

TABLE 2 - EQUATIONS USED FOR CALCULATION OF CONSTANT β IN EQUATION FOR ATMOSPHERIC RADIATION

Cloud Cover (tenths)	Equation
0	$\beta = 0.74 + 0.15\ e_a$
1	$\beta = 0.75 + 0.15\ e_a$
2	$\beta = 0.76 + 0.15\ e_a$
3	$\beta = 0.77 + 0.143\ e_a$
4	$\beta = 0.783 + 0.138\ e_a$
5	$\beta = 0.793 + 0.137\ e_a$
6	$\beta = 0.80 + 0.135\ e_a$
7	$\beta = 0.81 + 0.13\ e_a$
8	$\beta = 0.825 + 0.12\ e_a$
9	$\beta = 0.845 + 0.105\ e_a$
10	$\beta = 0.866 + 0.09\ e_a$

The vapor pressure of the air is calculated from the relative humidity, R, and the saturated vapor pressure. The vapor pressure of ambient air is equal to the saturated vapor pressure at the wet bulb temperature. The wet bulb temperature, T_{wb}, in °F, may be calculated from the relative humidity and air temperature by the equation

$$T_{wb} = (0.655 + 0.36\ R)\ T_a \tag{9}$$

Equation 9 is accurate up to a relative humidity of approximately 95 percent.

An equation for the saturated vapor pressure, e_s, was obtained by fitting an exponential equation to values of e_s and temperature by the non-linear least squares procedure. The resulting equation, for e_s in inches of mercury, is

$$e_s = \exp[17.62 - 9501/(T_{wb} + 460)] \tag{10}$$

The standard error of prediction of Equation 10 is 0.00335. The fit of the equation to the data is shown in Figure 3.

Since the reflectivity of the water surface to longwave radiation is 0.03, the absorbed longwave radiation can then be calculated as

$$H_a = 1.66 \times 10^{-9} \beta (T_a + 460)^4 \tag{11}$$

Back Radiation - Back radiation from the body of water to space is calculated as

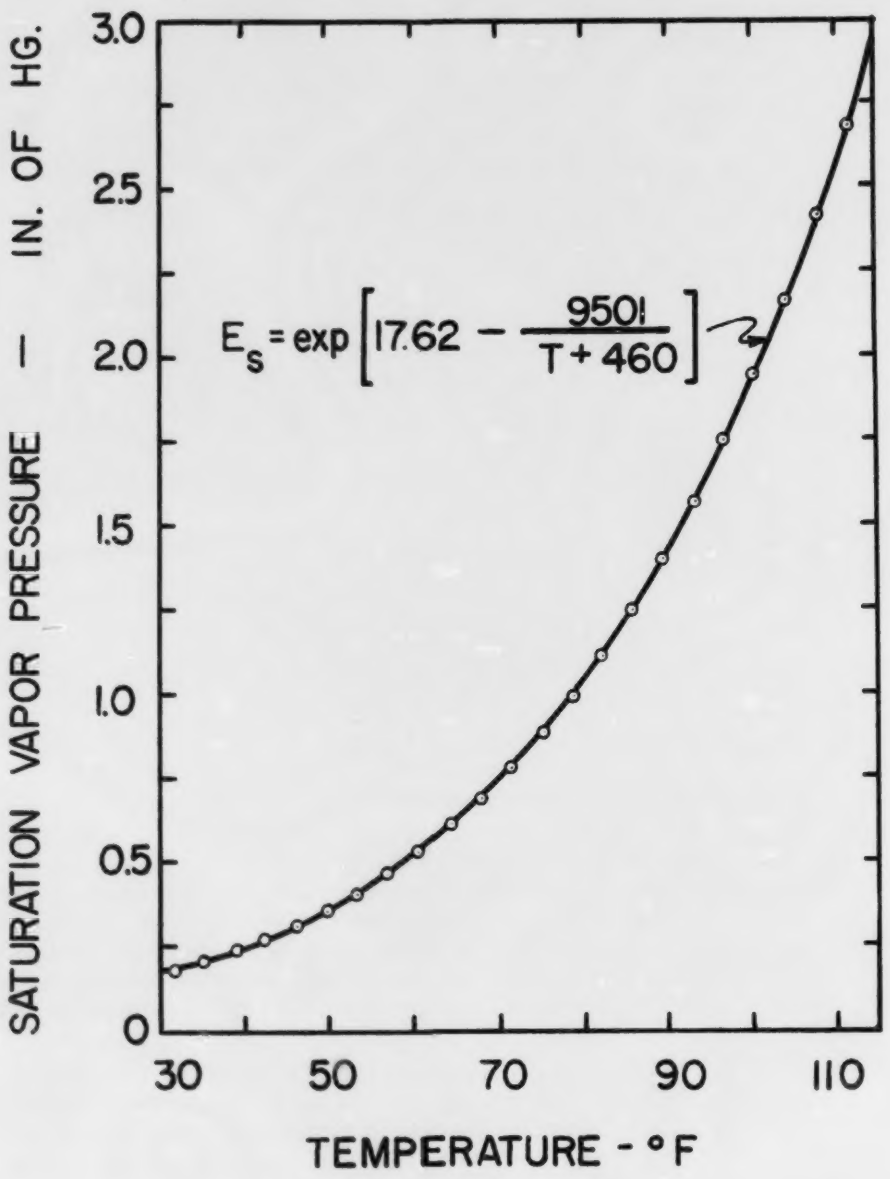


FIGURE 3 - EFFECT OF TEMPERATURE ON VAPOR PRESSURE

$$H_b = -0.97\ \sigma(T_w + 460)^4 \qquad (12)$$

where H_b is in BTU per square foot per hour, 0.97 is the emissivity of the water surface, and T_w is the temperature of the water surface in °F.

Evaporation - Evaporation is calculated from the formula

$$H_e = -C\ U(e_w - e_a) \qquad (13)$$

where C is an empirical constant which depends on the size, shape, and exposure of the water body, and on the location of the wind speed measurement, and varies from stream to reservoir conditions. U is the wind speed in miles per hour, e_w, is the saturated vapor pressure of the air at the temperature of the water surface, in inches of Hg, and e_a is the vapor pressure in the air in inches of Hg.

Equation 10 was used to calculate e_w by substituting T_w for T_{wb}. C was set equal to 13.9 for this study. This is approximately equal to the coefficient determined from the Lake Hefner studies, adjusted for the units used. However, it should be realized that C will vary somewhat from situation to situation, depending on local conditions.

Conduction - Heat conducted through the water surface was calculated as

$$H_c = 0.00543\ U\ P(T_a - T_w) \qquad (14)$$

where P is the atmospheric pressure in inches of mercury, which is calculated as

$$P = \frac{29.92}{\exp\left[\dfrac{32.15\ E}{1545\ (T_a + 460)}\right]} \qquad (15)$$

in which E is the elevation of the site in feet.

Equilibrium Temperature

The equilibrium temperature was determined by calculating H_t for an assumed equilibrium temperature and then correcting it until Equation 1 is satisfied. In this case, T_w - T_e becomes the correction to the assumed temperature. The heat exchange coefficient is calculated for each iteration as described below. The calculation procedure converges rapidly, and when the correction became less than 0.1°F, the calculation was terminated. When this occurred, H_t was generally less than ±3.0 BTU per square foot per day.

This method of calculation, while indirect and slower than the direct calculation proposed by Edinger and Geyer (3), is more accurate because it avoids the approximations necessary in their procedure. They were forced to approximate the expressions for heat loss due to back radiation and for vapor pressure by linear equations in order to solve the total heat budget equation for T_e.

Heat Exchange Coefficient

The expression given by Edinger and Geyer for the heat exchange coefficient is

$$K = 15.7 + (0.01025 + \eta)\ (333\ U) \tag{16}$$

when converted to the units used in this paper, where η is the slope of the vapor pressure vs. temperature curve, and U is the wind velocity in miles per hour. Certain approximations had to be made in order to define a linear heat exchange coefficient. However, Edinger and Geyer made a further linearization of the vapor pressure curve into segments of straight lines which introduces further inaccuracies and computational difficulty. This was found to be unnecessary in this study.

The slope of the vapor pressure curve can be found exactly at any temperature by differentiating the equation for saturated vapor pressure as a function of temperature. This gives

$$\eta = \frac{9501}{(T_w + 460)^2} \exp\left[17.62 - \frac{9501}{(T_w + 460)}\right] \tag{17}$$

In this study, T_e and K were computed at the same time. A new K was computed for each iteration by Equation 16, using the previously determined temperature. The final K was computed after T_e had been determined within 0.1°F. Since K is a function of water temperature, it should be noted that the value of K presented is only for the equilibrium temperature at that site for the same time. The actual value of K for a given pond depends on the temperature of the pond at that time. Since the pond temperature is higher than the equilibrium temperature (except possibly during the fall when the equilibrium temperature is falling rapidly) due to the added heat load from the plant, the actual value of K will be slightly higher than the value presented. However, the values of K presented for the equilibrium temperature are still useful for comparative purposes, because the change in K due to a given rise in pond temperature above equilibrium will be the same for each site.

A printout of the computer program used for calculating equilibrium temperature and heat exchange coefficients is shown in Appendix C.

Pond Temperature

The temperature of completely mixed cooling ponds of various sizes receiving a discharge from the standard plant was computed for each month of the year at each site for both normal and extreme meteorological conditions. The values of meteorological variables used were monthly averages, for reasons explained in the following section. Solar radiation was computed for the middle day of each month. The only pond characteristic (other than hydraulic behavior, which is theoretically comparable) which was not varied was the depth. In order to determine if the depth of the pond had a significant effect on the outlet temperature, the pond temperature for Nashville, Tennessee, was calculated for pond depths of both 15 and 25 feet. Based on the results, the depth is not a critical variable, as the greatest difference in the pond temperature caused by a 67 percent increase in depth was approximately 0.1°F, a negligible difference probably caused by rounding errors in the computer program. Depth theoretically should have no effect because, as the depth of a completely mixed pond is increased, so is the flow-through time. It is assumed that 15 feet is sufficient deep so that all energy is absorbed in the water column and does not reach the bottom sediments.

In the calculation procedure, the pond was assigned an arbitrary starting temperature (which was the pond temperature from the previous month, once the calculation procedure was underway) and was then subjected to the condenser water flow from the standard plant and to constant meteorological conditions representative of that month at that site for a series of four-day increments. The pond effluent temperature was assumed to be the mixed pond temperature and the influent temperature was assumed to be 15°F higher. At the end of each time increment, the change in temperature was computed and a new pond temperature determined. The iteration continued until the pond temperature stabilized. This was taken as the average effluent temperature for that month, and the program proceeded to the next month.

The calculation procedure closely followed that of Raphael. During any iteration or calculation period, the water temperature was assumed to be constant at the value calculated for the end of the previous iteration for the purposes of calculating surface heat transfer. When the calculations converged and the temperature correction became negligible, the water temperature was the same as that of the previous period, so no error was involved.

A printout of the computer program used to calculate pond temperatures is shown in Appendix D.

METEOROLOGICAL INFORMATION

Meteorological information used in calculating the terms in the heat budget was taken from the U. S. Weather Bureau's publication, "Local Climatological Data, Annual Summary with Comparative Data," for the various stations.

This publication presents the monthly averages and extremes of temperature, degree days, relative humidity, wind speed, cloud cover, and totals for precipitation data for the current year, and compares them with means and extremes.

The extreme conditions for monthly averages were derived from statistical analysis of the data over approximately the same period of record by the U. S. Weather Bureau's National Weather Records Center under contract with Vanderbilt University. The value used was the 10-percent value of the weather variable (the monthly average exceeded, on the average, once in 10 years). The 10-percent high values of temperature and relative humidity and the 10-percent low values of wind speed and cloud cover were used in order to obtain conditions conducive to maximum heating.

This study assumed that all four extreme conditions occurred simultaneously (in the same month) to produce the extreme heating conditions. Another Weather Bureau publication, "Statistical Summary of Hourly Observations," shows that maxima in these conditions tend to occur together at many stations and are usually associated with a stagnant high pressure system in summer. However, it is unlikely that all four 10-year extremes would occur in the same month. Therefore, the assumption of simultaneity probably represents a safety factor. The value of heating potential calculated from these 10-year extremes would thus probably have a return period somewhat greater than 10 years.

A trial computation using a month's data showed that the average of pond temperatures computed using hourly meteorological data matched the temperature computed using daily average values of data and that there was no consistent over or under-estimation. Once it has been determined that neglecting the diurnal cycle will cause little or no consistent error in computing the average temperature of large ponds of several days detention time, it is relatively easy to justify the use of monthly average values of meteorological data. This is so because the next shortest cycle is the yearly cycle, whose influence is preserved by using monthly averaging periods. There is much more similarity between daily averages and monthly averages than between hourly averages and daily averages because there is no regular cycle with a length between one day and one month to correspond to the diurnal cycle.

Because of the absence of a regular cycle between the daily cycle and the yearly cycle, the average weather data for the middle day in a month is approximately the same as the monthly average data. Thus, a curve connecting the monthly average data will also represent daily averages. Monthly average data was used in this study because it is more readily available, but the curves for monthly average results can also be used to find the daily average result to be expected (on the average). This is not true of the results for extreme heating conditions, however. Daily extremes will be higher than monthly extremes.

RESULTS FOR EACH STATION

The meteorological information used for each station was tabulated on a standard form, an example of which is shown as Figure 4. The standard form was used for several projects and included a column for precipitation, which was not used in this study. The data for all stations analyzed, alphabetized by states, is presented in Appendix A. All the input necessary for the computer program is contained on each data sheet.

The results from each station were plotted on a standard graph, an example of which is shown as Figure 5. The variation of the equilibrium temperature throughout the year is shown in the upper left-hand portion of each graph, both for normal and extreme conditions. The variation of the heat exchange coefficient throughout the year is shown in the upper right-hand portion of each graph, both for normal and extreme conditions. The lower two portions of each graph depict the variation of pond temperature for completely mixed, recirculating ponds of 1000, 2000, and 3000 acres receiving the heated condenser water discharge from the 1000-mw standard plant. The left-hand portion shows the pond temperatures under average meteorological conditions, and the right-hand portion shows the pond temperature under extreme meteorological conditions conducive to heating. In all portions of all graphs, the solid curves are for average conditions, and the dashed curves are for the extreme conditions. The graphs presenting results from all the stations analyzed are collected in Appendix B, alphabetized by states.

Data from a total of 88 stations were analyzed. Extreme values of monthly averages for 7 stations could not be calculated with accuracy, because of the length of record involved. Thus, trends of extreme monthly values are based on the analysis of data from 81 stations.

At least one station from each state was analyzed, and for large states or states with a great variation in climate or topography from one part of the state to another, as many as 3 stations were used. A finer subdivision would have produced more accurate representation on the maps used to display trends in the results.

An examination of the results from each station will show that they are remarkably similar in pattern, but different in magnitude. Only a few general comments will be presented here, as the results of each station are generally self-explanatory.

Equilibrium Temperature

The equilibrium temperature graph for almost all stations shows a low about December 31 and a high in mid or late July. The pattern of variation throughout the year is quite smooth and regular. The difference between high and low for the year and the sharpness of the summer peak and winter valley increase with latitude.

Heat Exchange Coefficient

The heat exchange coefficient shows a pattern of variation almost the same as that of equilibrium temperature, which is extremely helpful from the

WEATHER INFORMATION FOR Nashville, Tennessee (13897)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	7.1	39.0	.71		9.0	5.3	45.0	.815		6.35
FEB	6.7	41.0	.63		9.2	4.7	46.3	.77		6.4
MAR	6.5	49.5	.60		9.9	5.0	53.0	.735		7.2
APR	6.2	59.5	.64		9.4	5.0	63.5	.70		7.0
MAY	5.9	68.3	.68		7.5	4.0	70.8	.73		4.9
JUNE	5.5	76.3	.69		6.7	4.0	78.0	.76		4.4
JULY	5.7	79.4	.75		6.2	4.0	81.0	.773		3.7
AUG	5.3	78.3	.76		5.9	3.0	79.5	.78		3.9
SEPT	5.0	72.2	.76		6.2	2.7	74.0	.78		4.0
OCT	4.6	61.0	.66		6.3	1.5	63.0	.78		4.35
NOV	5.9	48.9	.68		8.2	3.7	51.0	.738		5.4
DEC	6.7	41.0	.69		8.6	4.7	44.5	.77		6.2

LATITUDE = 36° 07' N

LONGITUDE = 86° 41' W

ELEVATION = 590 ft.

*Extreme conditions given in knots

FIGURE 4 - SAMPLE DATA SHEET FOR METEOROLOGICAL INFORMATION

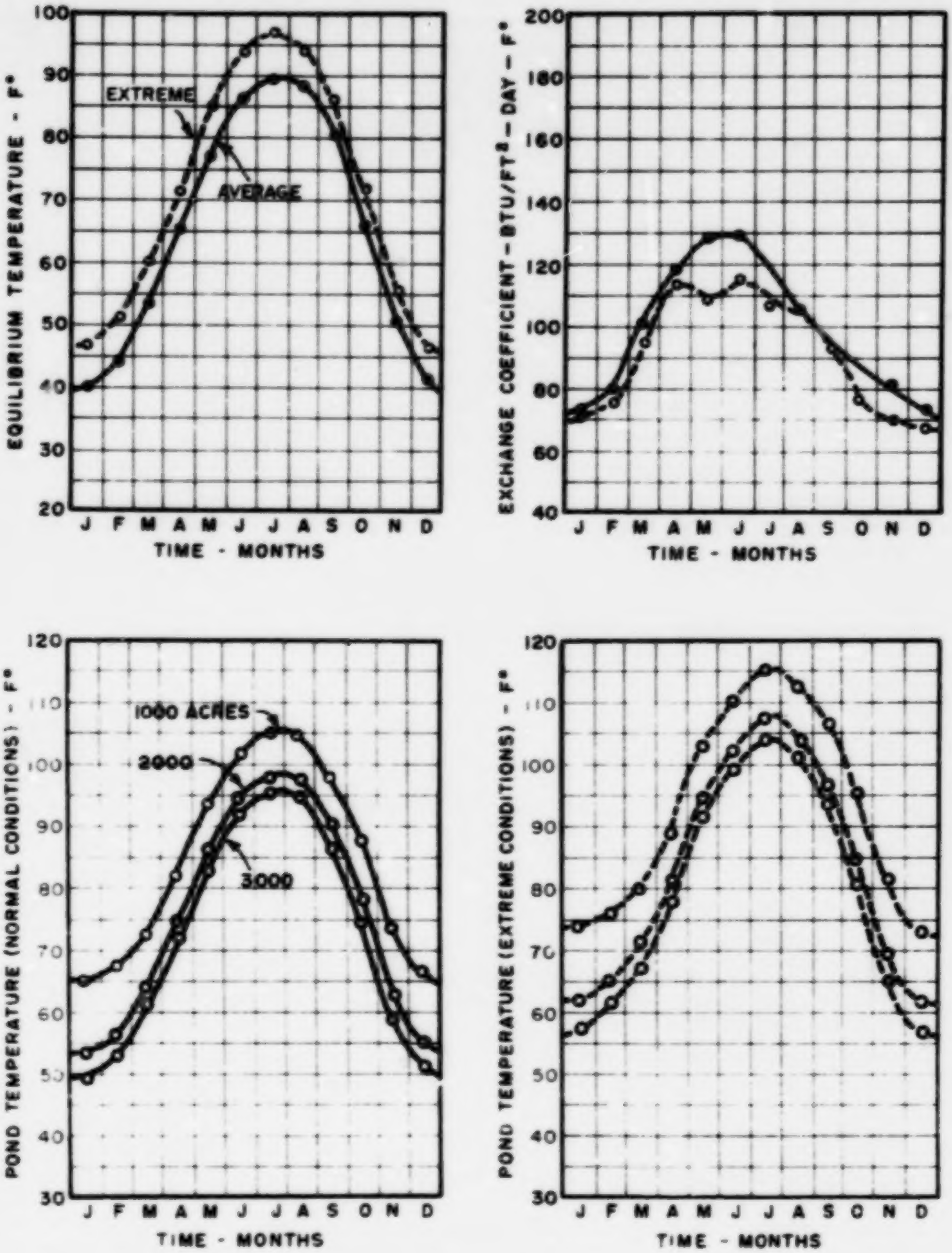


FIGURE 5 - SAMPLE GRAPH OF RESULTS FOR A SINGLE STATION (NASHVILLE, TENNESSEE)

point of view of the efficient operation of cooling ponds. The highest heat exchange coefficients usually occur in mid or early July and the lowest usually occur about December 31. Thus, heat exchange is greatest when temperatures are highest and the potential for lowering the efficiency of an electric generating station because of excessive cooling water temperatures is at or near its peak.

Deviations from the smooth pattern of annual variation are more common for the heat exchange coefficient than for the equilibrium temperature. The primary cause for the increase in the heat exchange coefficient during the summer is the increase in evaporation and back radiation due to the higher water temperature. This is slightly offset for most stations by lower average wind speeds during the summer. Higher wind speeds during certain parts of the year at individual stations cause significant deviation from the trend (particularly at coastal stations). For instance, the Florida stations show an increase in the heat exchange coefficient in September and October, which is the hurricane season.

The heat exchange coefficient under extreme heating conditions is generally lower than for normal conditions. This is because the increase due to higher water temperatures (see the graph of equilibrium temperature under extreme heating conditions) is not enough to offset the decrease due to lower wind velocities. In addition, the curves for extreme heating conditions are less regular and show more deviation from a smooth curve than the curves for the heat exchange coefficient under normal conditions.

Mixed Pond Temperature

The curves showing the variation of mixed pond temperature are essentially the equilibrium temperature curve plus the heating effect of the heated condenser water. The heating effect is a function of the heat exchange coefficient, which is higher during the summer than during the winter. The heating effect is therefore greater during the winter than during the summer. Thus, the mixed pond temperature is higher than equilibrium by a greater amount during the winter than during the summer. Consequently, the curves for mixed pond temperature show less of a swing from winter low to summer high than the curves for equilibrium temperature.

The extra cooling which occurs during the summer is caused by (or described by) the increase in the heat exchange coefficient during the summer. As shown by Equation 16, K is a direct function of η, and Equation 10 and Figure 3 show that η rises with increasing water temperature. This more than offsets the slight decrease in wind speed during the summer noted at most stations and results in a net increase in K.

The curves for mixed pond temperature under extreme heating conditions are higher than those for normal meteorological conditions by approximately the same increment as that between the curves for equilibrium temperature under extreme and normal meteorological conditions. However, at the stations where the heat exchange coefficient for extreme conditions is significantly lower than the coefficient under normal conditions, the mixed pond temperature under extreme heating conditions will exceed the mixed pond temperature under normal conditions by a greater increment than the difference between the average and extreme equilibrium temperature curves. The difference between the mixed pond temperature under normal conditions and that under extreme heating conditions rarely exceeds the difference between the equilibrium temperature curves by more than one to three degrees.

As a consequence of the close similarity between the curves for mixed pond temperature and those for equilibrium temperature, the mixed pond temperature usually shows a high in mid or late July, with a low about December 31. The curves are generally quite smooth and regular, but the curves for extreme heating conditions show more irregularity because the curve for the heat exchange coefficient under extreme conditions is not usually as smooth as that for normal conditions.

The excess of mixed pond temperature over equilibrium temperature is obviously a function of pond size. As the pond is made larger, the effect of the heated condenser water in raising the pond temperature above equilibrium temperature becomes less, and as the pond size increases to infinity, the mixed pond temperature decreases to the equilibrium temperature.

The effect of increasing pond size can be clearly seen in Figure 5. The pond temperature decreases as the surface area increases, but successive increments in pond size produce smaller increments of temperature decrease and have less and less effect as the mixed pond temperature approaches equilibrium temperature. By plotting the mixed pond temperature vs. surface area for various seasons or critical times, the engineer or planner can easily get a quick idea of what size pond would be necessary to meet given objectives in a given situation. This type of plot is illustrated in Figure 6. Figure 6 was constructed from the data presented in Figure 5.

Figure 6 shows that pond size has a much greater effect on pond temperature in January when the heat exchange coefficient is low than it does in July when the heat exchange coefficient is higher. Figure 6 shows that a mixed cooling pond for a 1000-mw plant near Nashville, Tennessee, would have to have a surface area of approximately 3000 acres in order to keep the mixed pond temperature within 5°F of the equilibrium temperature under normal meteorological conditions. The same criterion would require a pond of at least 5000 acres in January.

The same type of analysis using data for extreme heating conditions will show that a pond of approximately 3400 acres would be needed in July and approximately 5000 acres in January. Since the highest intake temperature to be encountered is the critical design variable, a pond of about 3500 acres might be selected in this case.

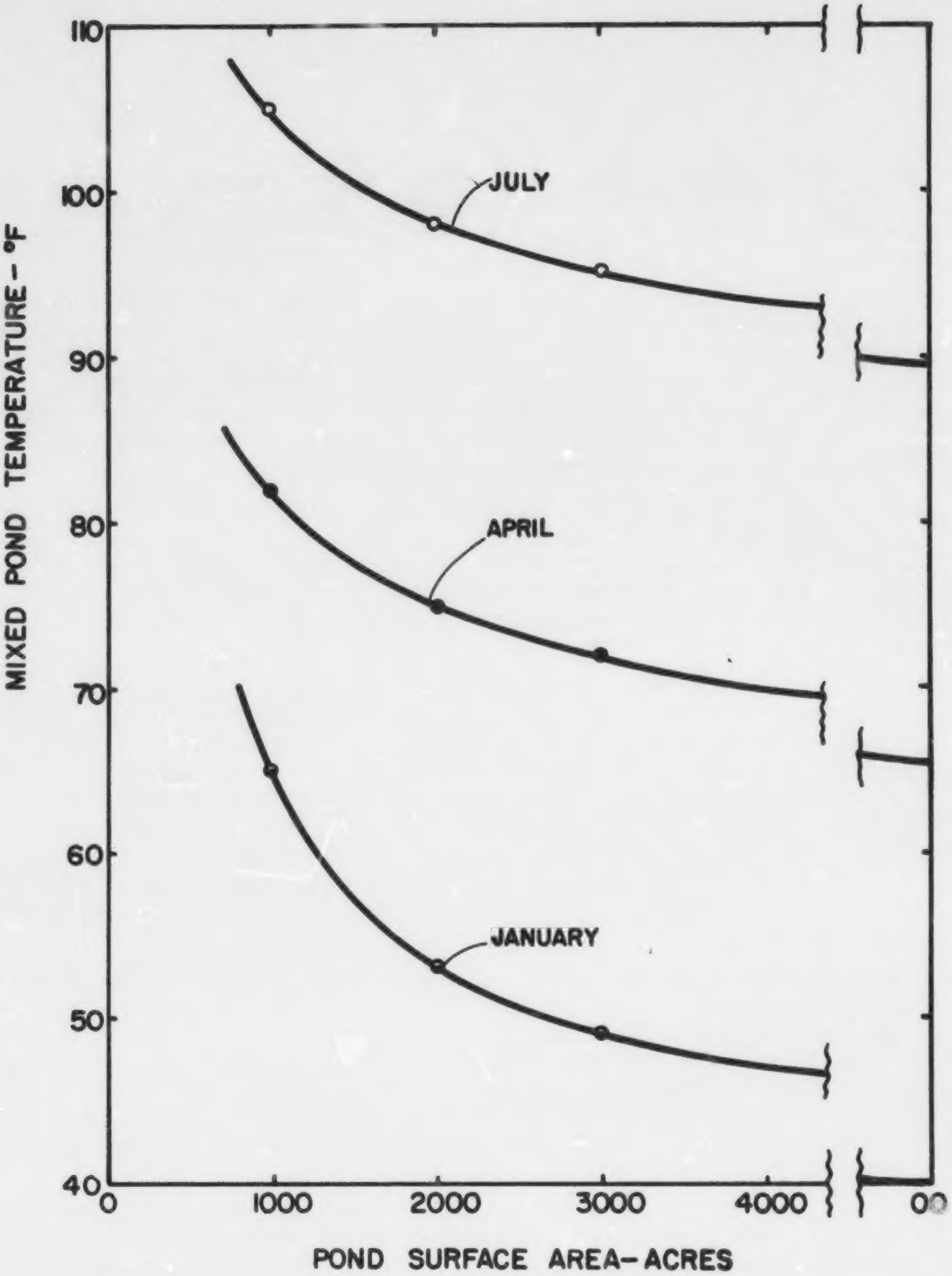


FIGURE 6 - EFFECT OF POND SURFACE AREA ON MIXED POND TEMPERATURE FOR VARIOUS SEASONS UNDER NORMAL METEOROLOGICAL CONDITIONS, NASHVILLE, TENNESSEE

EFFECT OF GEOGRAPHICAL LOCATION ON POND PERFORMANCE

The effects of geographical location on equilibrium temperatures, heat exchange coefficients, and cooling pond performance are shown by a series of maps of the United States, Figures 7-44. Each map shows the variation of a particular variable at a particular time of year, with lines connecting points of equal value, similar to contour lines. The points on the maps show the location of the weather stations used to plot the contours.

Three general categories of maps are presented. These are maps depicting: (1) the variation of equilibrium temperature at various times of the year, both for average and extreme heating conditions; (2) the variation of the heat exchange coefficient at various times of the year, both for average and extreme heating conditions; and (3) the mixed pond temperature for the standard plant and a particular size cooling pond at various times of the year, both for average and extreme heating conditions.

Examination of Figure 7-16 shows that latitude, which controls solar radiation, is the main influence on the equilibrium temperature. The variation of other parameters is masked by the heavy influence of solar radiation.

Figures 17-20 show, however, that topographic conditions, which strongly influence wind speed and the wet bulb temperature (the variables which determine K), have a strong influence on the heat exchange coefficient. These maps show that the best cooling conditions exist on the southern great plains between the Rocky Mountains and the Mississippi River, and secondarily, along the Gulf and Atlantic Coasts, all the way to Cape Cod. Poor cooling conditions for ponds exist along the West Coast and in the vicinity of the Appalachian and Rocky Mountains. The area most conducive to the use of cooling ponds seems to be Texas, while the area least suitable seems to be the area between the Sierra Nevada and Rocky Mountains.

The figures depicting the variation of mixed pond temperature, Figures 21-44, are similar to the figures showing equilibrium temperature but with distortions in the lines caused by the variations in heat exchange coefficients across the country. The pond temperature rises as one goes further north, except along the Gulf Coast and occasionally along the northern Pacific Coast. However, the equal temperature lines do not run east and west as uniformly as the equal equilibrium temperature lines, but show marked dips, or temperature decreases, across the great plains from Texas to the Dakotas, and rises across the Rocky and Appalachian Mountains, and into New England. This is due to the higher heat exchange coefficients across the great plains and the lower coefficients in the mountains and in New England (except for the Long Island to Cape Cod coast, where heat exchange coefficients are significantly higher than they are 100 to 200 miles inland).

It should be emphasized, however, that the contours in the vicinity of mountainous areas refer to conditions at the weather stations, which are usually at airports. For the purpose of this study, this is much more appropriate than a station in the actual mountainous area, since cooling ponds are much more likely to be built in the lower level areas in the valleys than in the rough country on the side of a mountain.

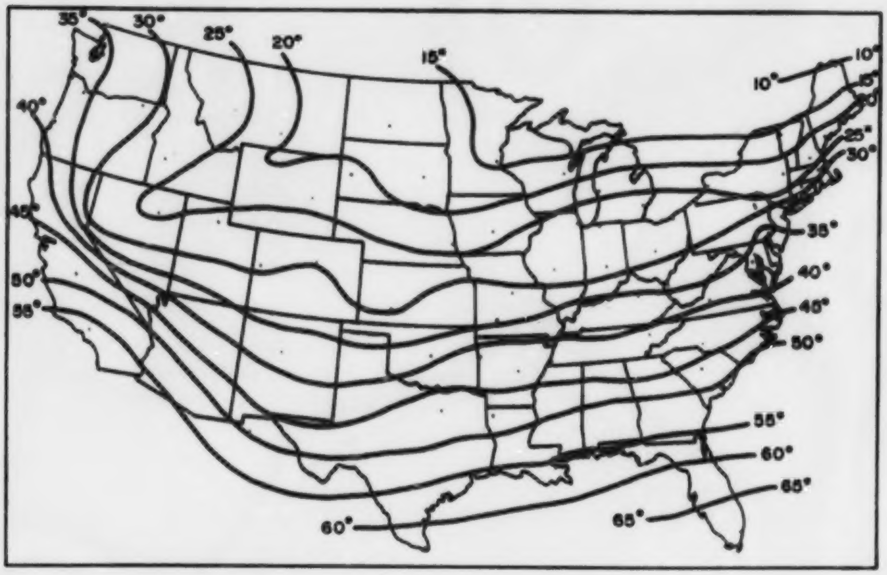

35°
30°
25°
20°
15°
10°
10°
15°
20°
25°
30°
40°
45°
50°
55°
35°
40°
45°
50°
55°
60°
65°
60°
65°

FIGURE 7 - EQUILIBRIUM TEMPERATURE ON JANUARY 1 - MONTHLY AVERAGE FOR AVERAGE WEATHER CONDITIONS

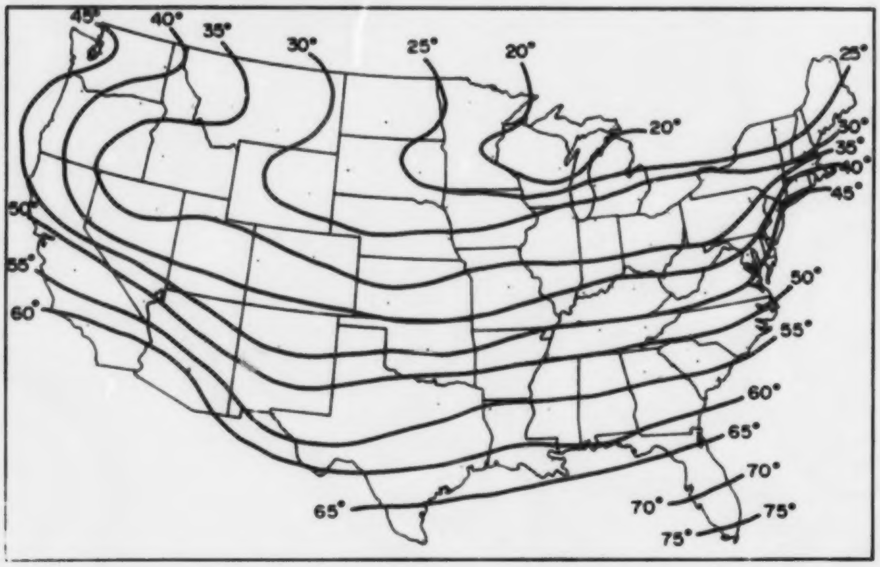

45°
40°
35°
30°
25°
20°
25°
20°
30°
35°
40°
45°
50°
55°
60°
50°
55°
60°
65°
70°
65°
70°
75°
75°

FIGURE 8 - EQUILIBRIUM TEMPERATURE ON JANUARY 1 - MONTHLY AVERAGE FOR EXTREME WEATHER CONDITIONS

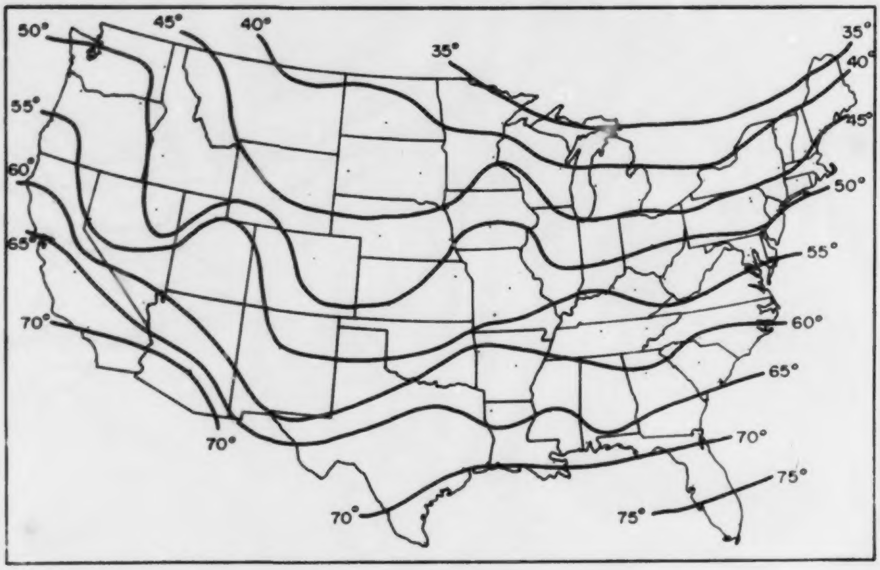

50°
45°
40°
35°
35°
40°
55°
45°
60°
50°
65°
55°
70°
60°
65°
70°
70°
75°
70°
75°

FIGURE 9 - EQUILIBRIUM TEMPERATURE ON APRIL 1 - MONTHLY AVERAGE FOR AVERAGE WEATHER CONDITIONS

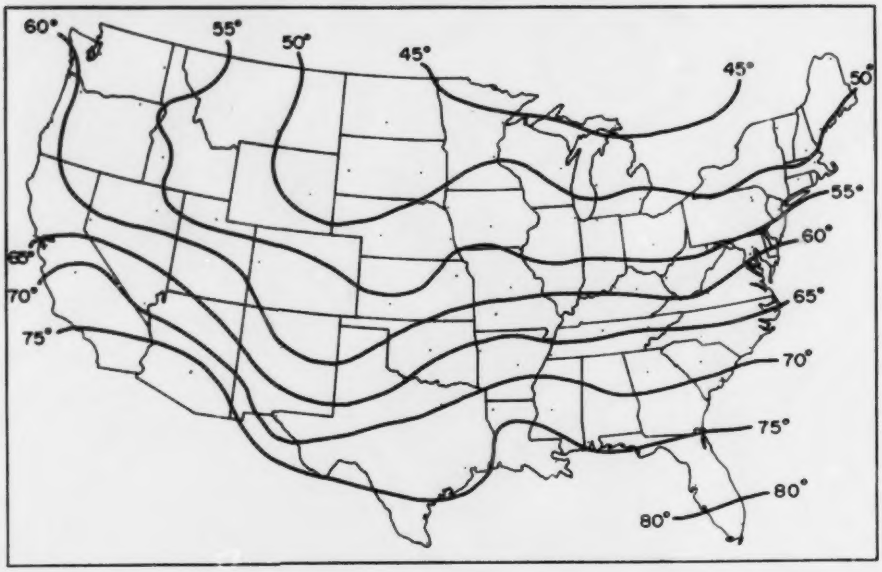

60°
55°
50°
45°
45°
50°
55°
65°
60°
70°
65°
75°
70°
75°
80°
80°

FIGURE 10 - EQUILIBRIUM TEMPERATURE ON APRIL 1 - MONTHLY AVERAGE FOR EXTREME WEATHER CONDITIONS

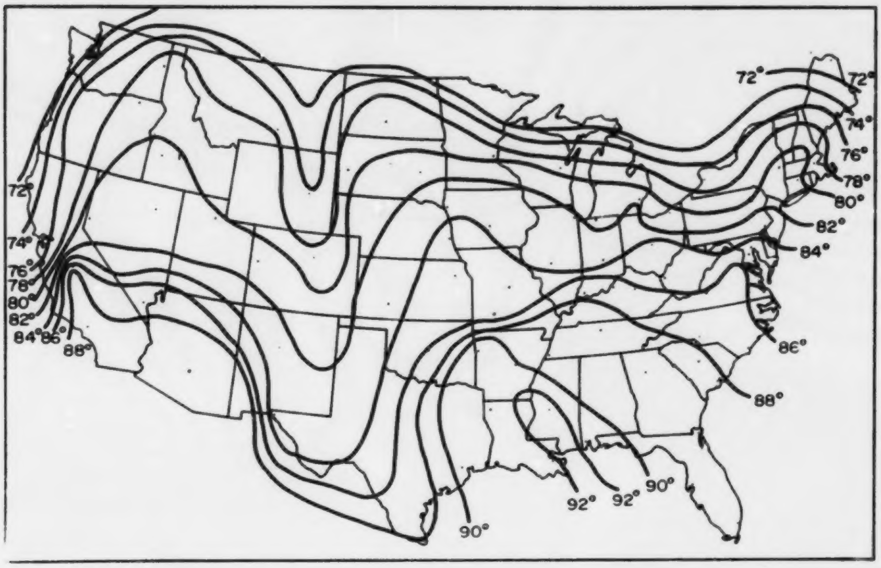

72°
72°
74°
76°
78°
80°
82°
84°
86°
88°
90°
92°
92°
90°
72°
74°
76°
78°
80°
82°
84°
86°
88°

FIGURE 11 - EQUILIBRIUM TEMPERATURE ON JULY 1 - MONTHLY AVERAGE FOR AVERAGE WEATHER CONDITIONS

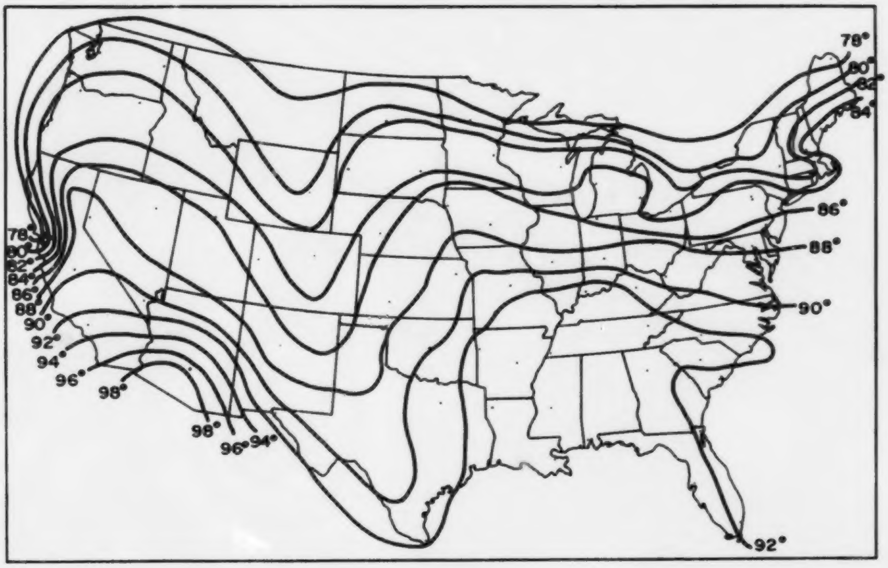

78°
80°
82°
84°
86°
88°
90°
92°
78°
80°
82°
84°
86°
88°
90°
92°
94°
96°
98°
98°
96°
94°

FIGURE 12 - EQUILIBRIUM TEMPERATURE ON JULY 1 - MONTHLY AVERAGE FOR EXTREME WEATHER CONDITIONS

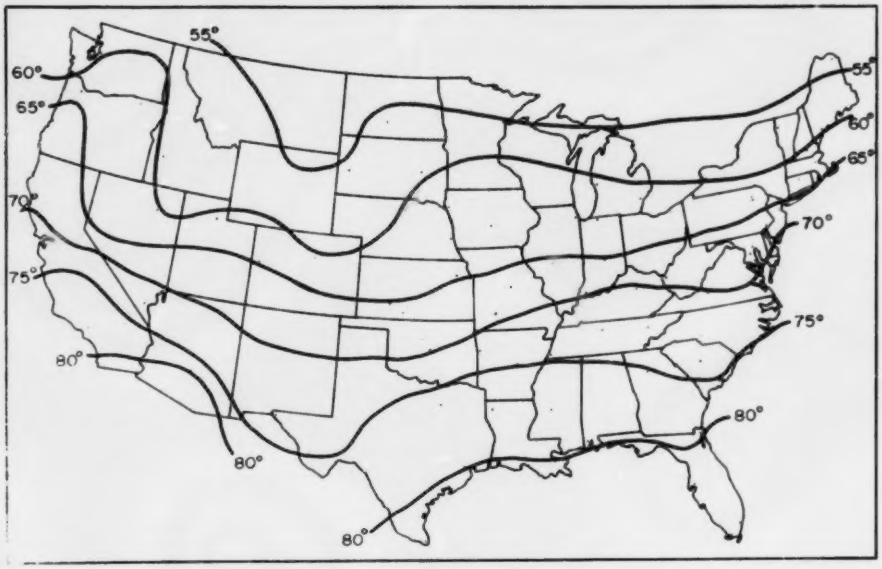

55°
60°
65°
70°
75°
80°
80°
80°
55°
60°
65°
70°
75°
80°

FIGURE 13 - EQUILIBRIUM TEMPERATURE ON OCTOBER 1 - MONTHLY AVERAGE FOR AVERAGE WEATHER CONDITIONS

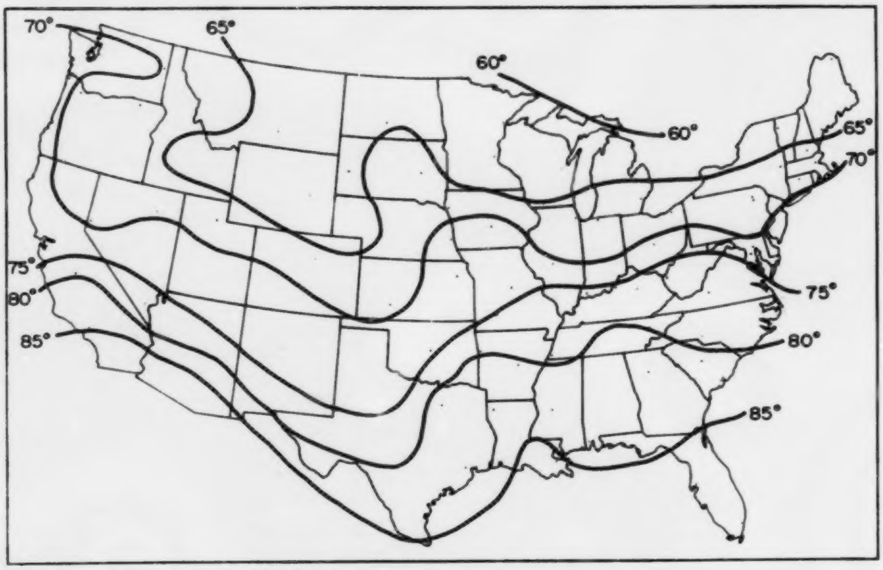

70°
65°
60°
60°
75°
80°
85°
65°
70°
75°
80°
85°

FIGURE 14 - EQUILIBRIUM TEMPERATURE ON OCTOBER 1 - MONTHLY AVERAGE FOR EXTREME WEATHER CONDITIONS

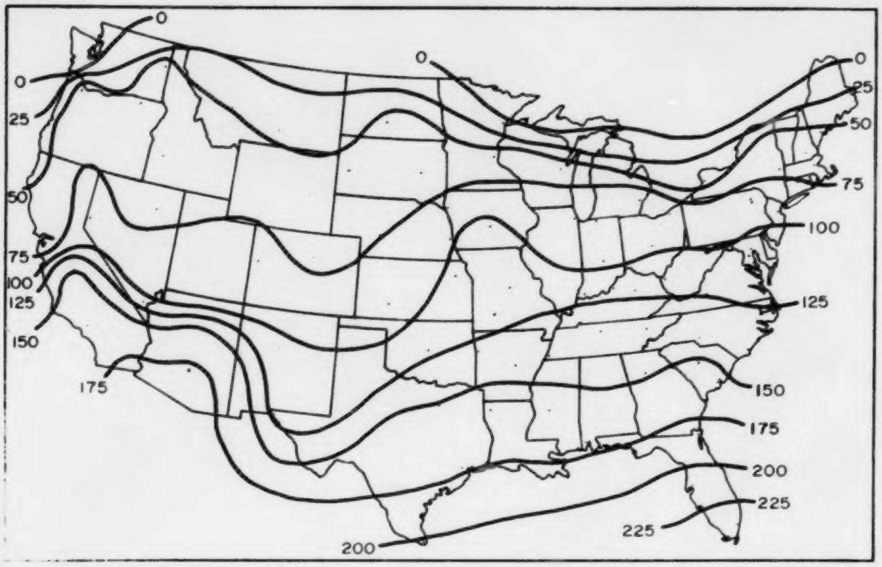

0
0
0
0
25
25
50
50
75
75
100
100
125
125
150
150
175
175
200
200
225
225

FIGURE 15 - TIME (IN DAYS) THAT MONTHLY AVERAGE EQUILIBRIUM TEMPERATURE FOR AVERAGE WEATHER CONDITIONS IS ABOVE 75°F

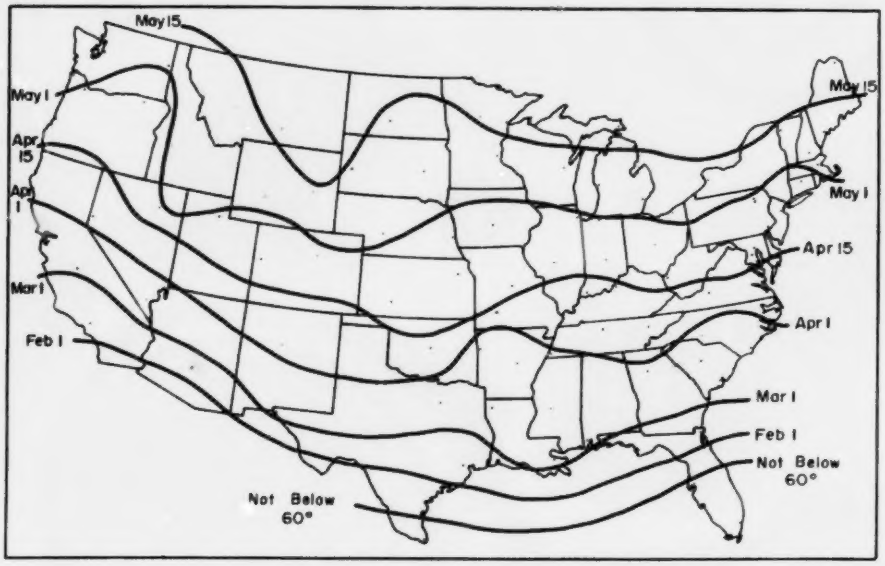

May 15
May 1
Apr 15
Apr 1
Mar 1
Feb 1
May 15
May 1
Apr 15
Apr 1
Mar 1
Feb 1
Not Below 60°
Not Below 60°

FIGURE 16 - DATE ON WHICH MONTHLY AVERAGE EQUILIBRIUM TEMPERATURE FOR AVERAGE WEATHER CONDITIONS RISES THROUGH 60°F IN THE SPRING

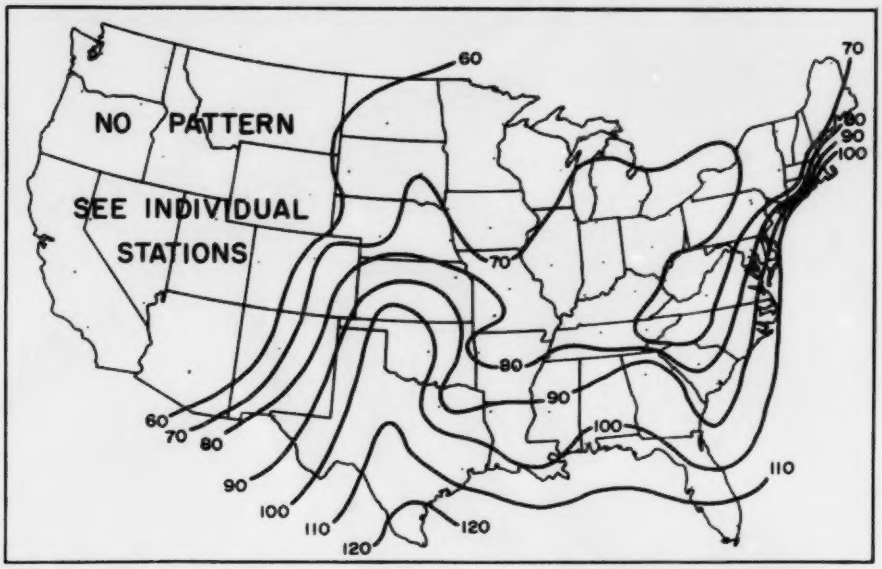

60
70
80
90
100
NO PATTERN
SEE INDIVIDUAL STATIONS
70
80
90
100
110
60
70
80
90
100
110
120
120

FIGURE 17 - HEAT EXCHANGE COEFFICIENT ON JANUARY 1 - MONTHLY AVERAGE FOR AVERAGE WEATHER CONDITIONS (BTU/SQ FT-DAY-°F)

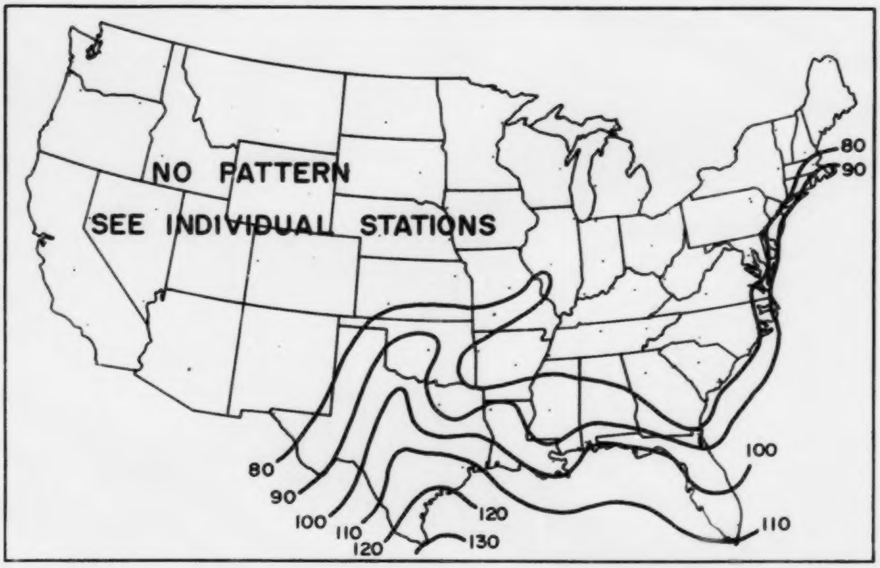

80
90
NO PATTERN
SEE INDIVIDUAL STATIONS
100
80
90
100
110
120
120
130
110

FIGURE 18 - HEAT EXCHANGE COEFFICIENT ON JANUARY 1 - MONTHLY AVERAGE FOR EXTREME WEATHER CONDITIONS (BTU/SQ FT-DAY-°F)

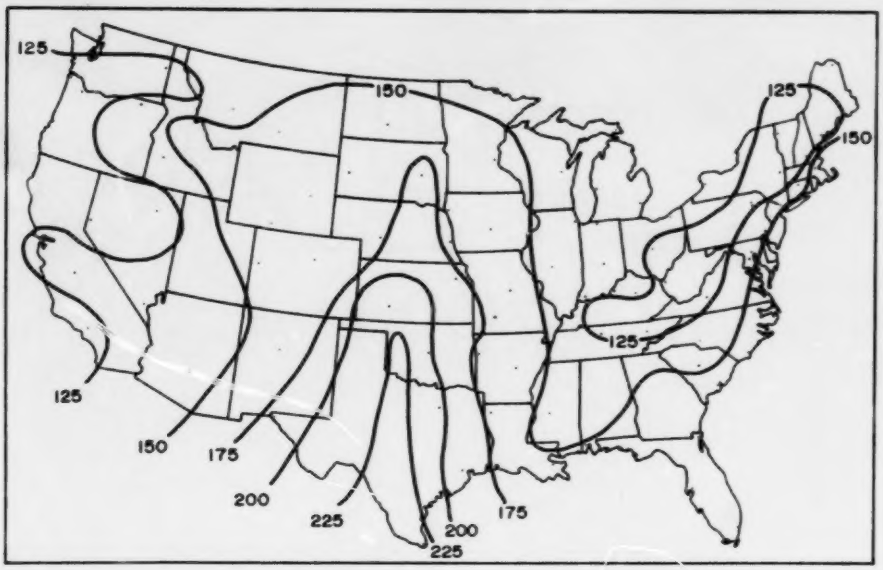

125
150
125
150
125
125
150
175
200
225
200
225
175

FIGURE 19 - HEAT EXCHANGE COEFFICIENT ON JULY 1 - MONTHLY AVERAGE FOR AVERAGE WEATHER CONDITIONS (BTU/SQ FT-DAY-°F)

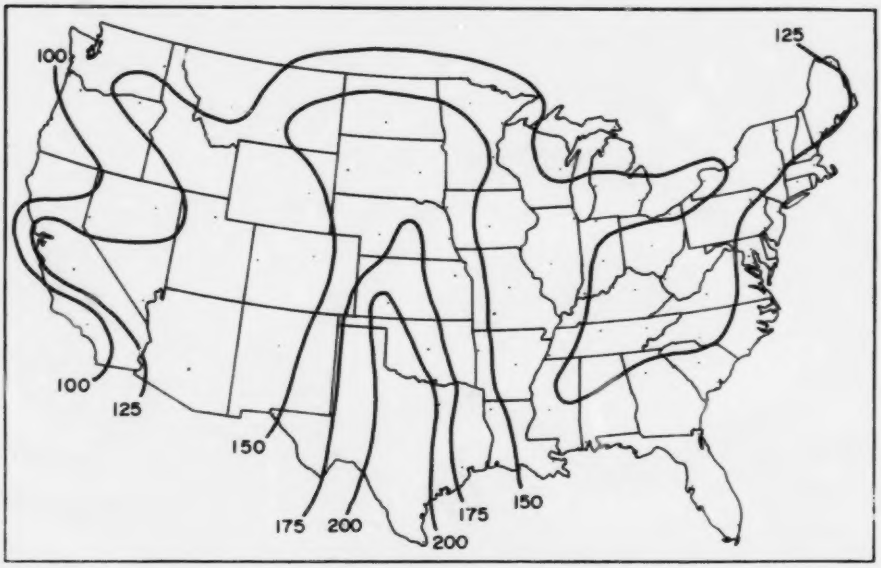

100
125
100
125
150
175
200
200
175
150

FIGURE 20 - HEAT EXCHANGE COEFFICIENT ON JULY 1 - MONTHLY AVERAGE FOR EXTREME WEATHER CONDITIONS (BTU/SQ FT-DAY-°F)

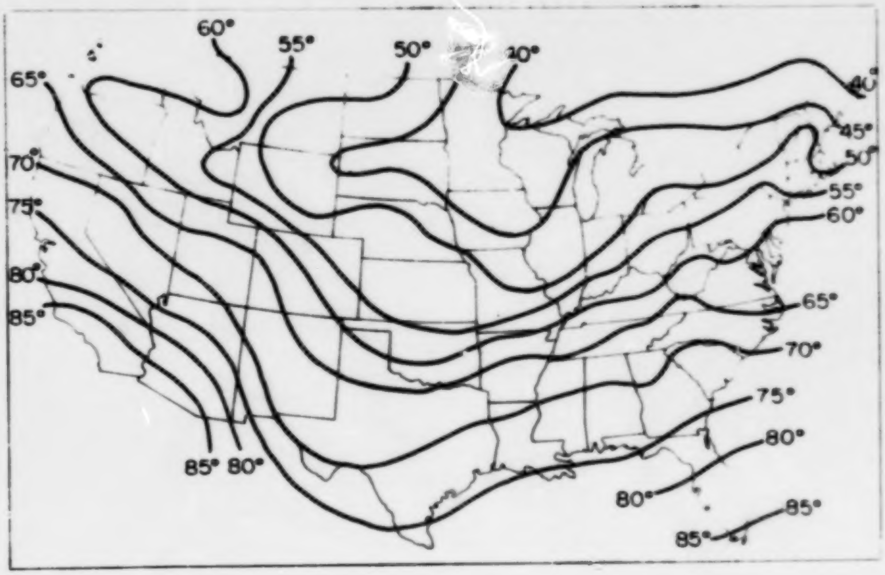

60°
55°
50°
40°
65°
40°
45°
50°
70°
55°
75°
60°
80°
85°
65°
70°
75°
80°
85°
80°
80°
85°
85°

FIGURE 21 - TEMPERATURE, IN °F, OF 1000-ACRE POND ON JANUARY 1, NORMAL METEOROLOGICAL CONDITIONS

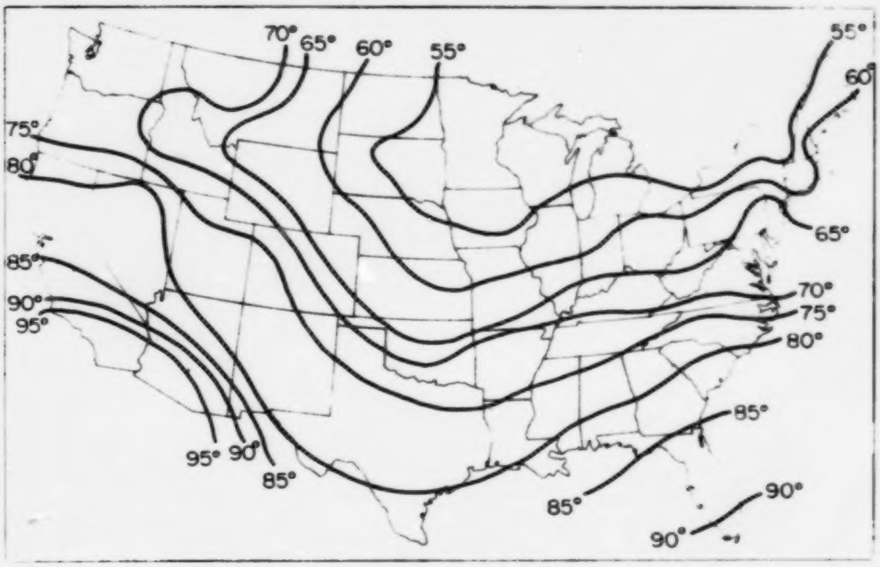

70°
65°
60°
55°
55°
60°
75°
80°
65°
85°
70°
75°
90°
95°
80°
95°
90°
85°
85°
85°
90°
90°

FIGURE 22 - TEMPERATURE, IN °F, OF 1000-ACRE POND ON JANUARY 1, EXTREME METEOROLOGICAL CONDITIONS

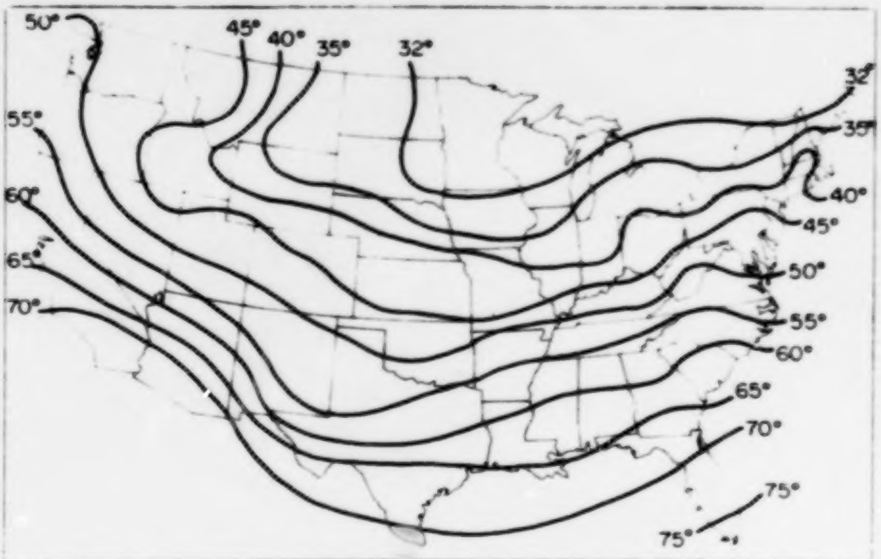

50°
45°
40°
35°
32°
32°
35°
55°
40°
60°
45°
65°
50°
70°
55°
60°
65°
70°
75°
75°

FIGURE 23 - TEMPERATURE, IN °F, OF 2000-ACRE POND ON JANUARY 1, NORMAL METEOROLOGICAL CONDITIONS

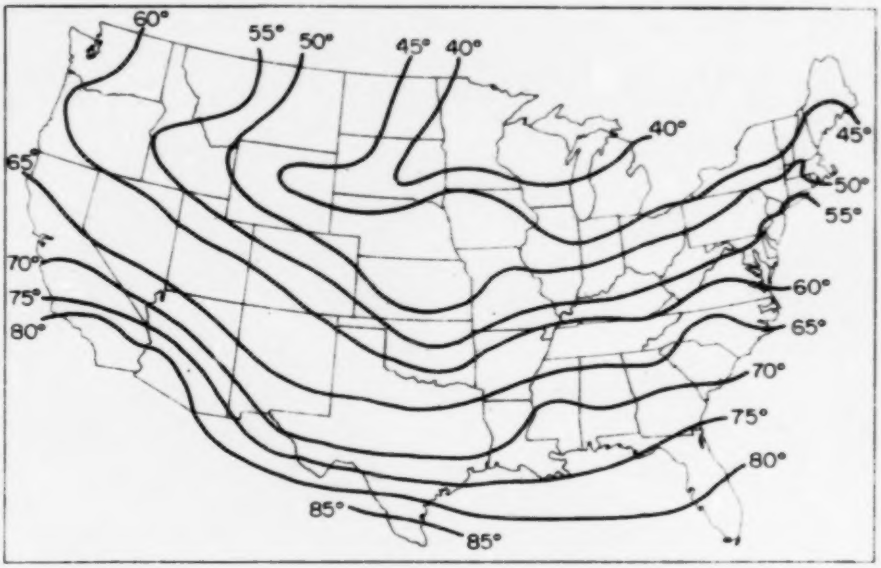

60°
55°
50°
45°
40°
40°
45°
65°
50°
55°
70°
75°
80°
60°
65°
70°
75°
80°
85°
85°

FIGURE 24 - TEMPERATURE, IN °F, OF 2000-ACRE POND ON JANUARY 1, EXTREME METEOROLOGICAL CONDITIONS

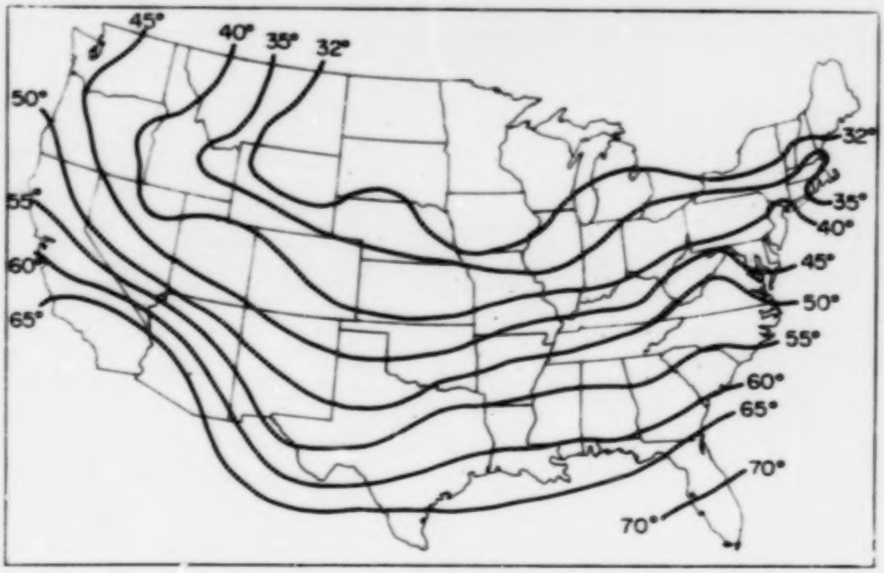

45°
40°
35°
32°
50°
55°
60°
65°
32°
35°
40°
45°
50°
55°
60°
65°
70°
70°

FIGURE 25 - TEMPERATURE, IN °F, OF 3000-ACRE POND ON JANUARY 1, NORMAL METEOROLOGICAL CONDITIONS

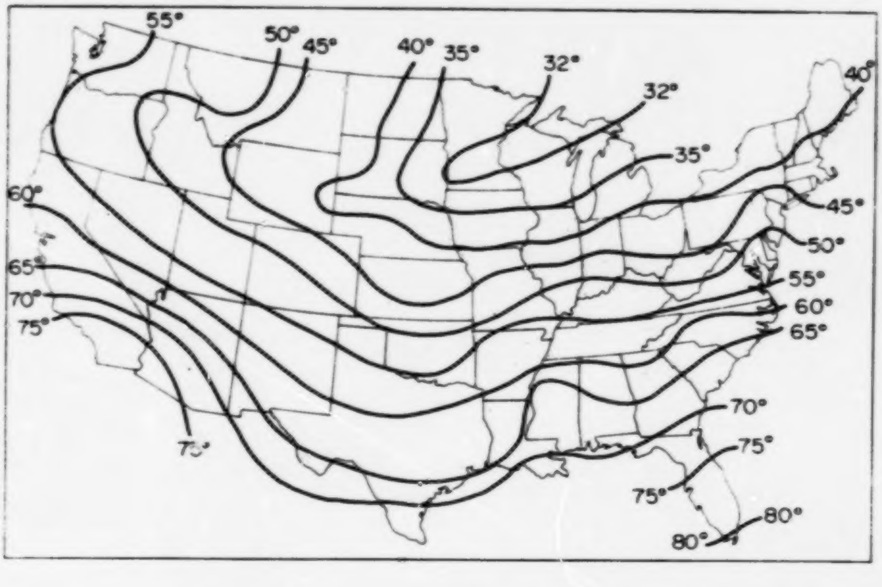

55°
50°
45°
40°
35°
32°
32°
40°
35°
60°
65°
70°
75°
45°
50°
55°
60°
65°
70°
75°
75°
75°
80°
80°

FIGURE 26 - TEMPERATURE, IN °F, OF 3000-ACRE POND ON JANUARY 1, EXTREME METEOROLOGICAL CONDITIONS

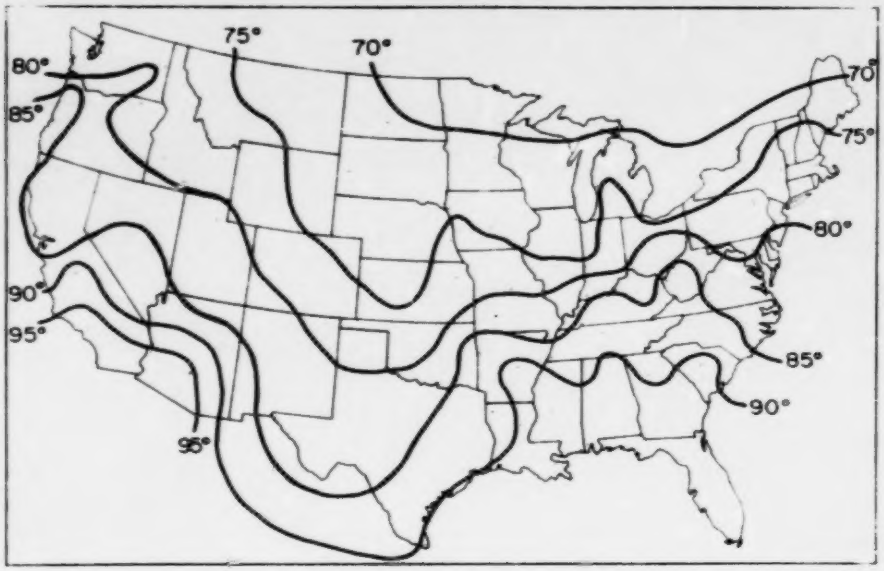

75°
70°
80°
85°
70°
75°
80°
90°
95°
85°
90°
95°

FIGURE 27 - TEMPERATURE, IN °F, OF 1000-ACRE POND ON MAY 1, NORMAL METEOROLOGICAL CONDITIONS

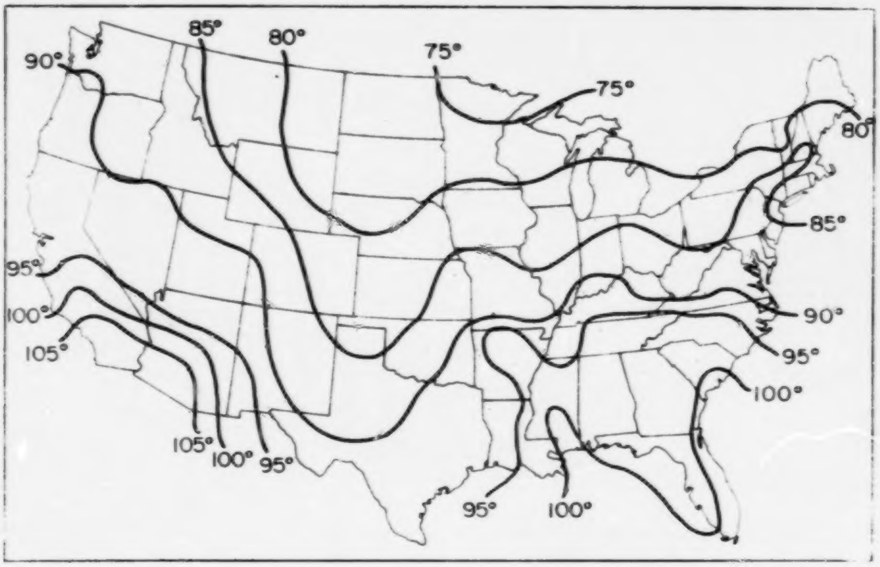

85°
80°
90°
75°
75°
80°
85°
95°
90°
100°
95°
105°
100°
105°
100°
95°
95°
100°

FIGURE 28 - TEMPERATURE, IN °F, OF 1000-ACRE POND ON MAY 1, EXTREME METEOROLOGICAL CONDITIONS

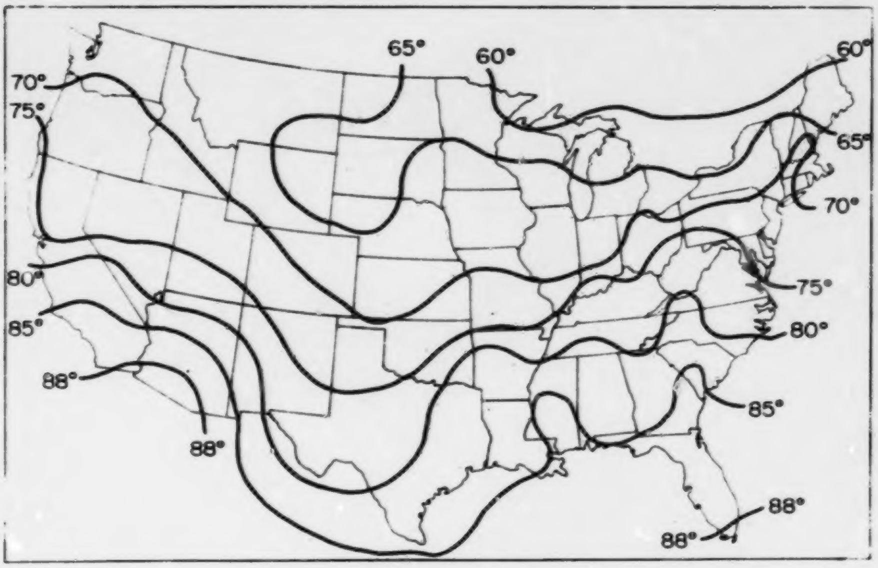

65°
60°
60°
70°
75°
65°
70°
80°
75°
80°
85°
88°
85°
88°
88°
88°

FIGURE 29 - TEMPERATURE, IN °F, OF 2000-ACRE POND ON MAY 1, NORMAL METEOROLOGICAL CONDITIONS

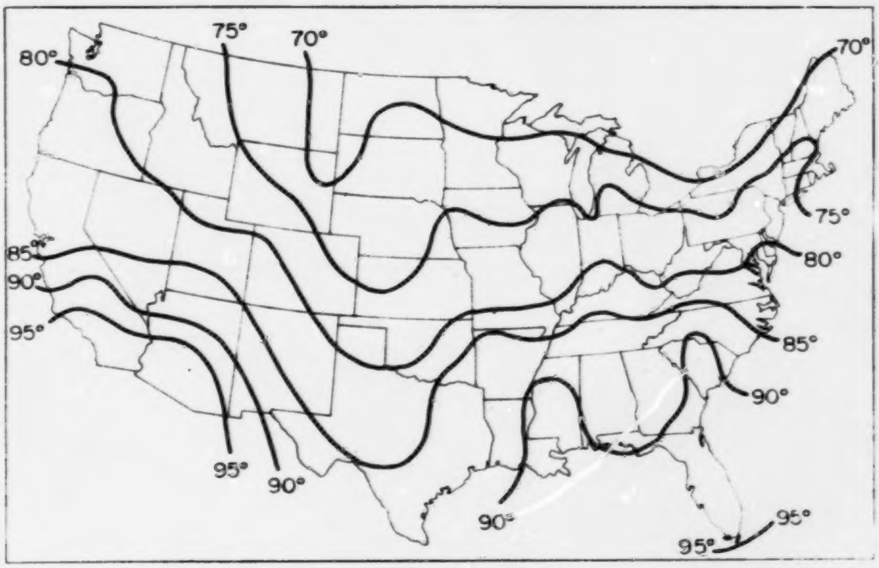

75°
70°
80°
70°
75°
85°
80°
90°
95°
85°
90°
95°
90°
90°
95°
95°

FIGURE 30 - TEMPERATURE, IN °F, OF 2000-ACRE POND ON MAY 1, EXTREME METEOROLOGICAL CONDITIONS

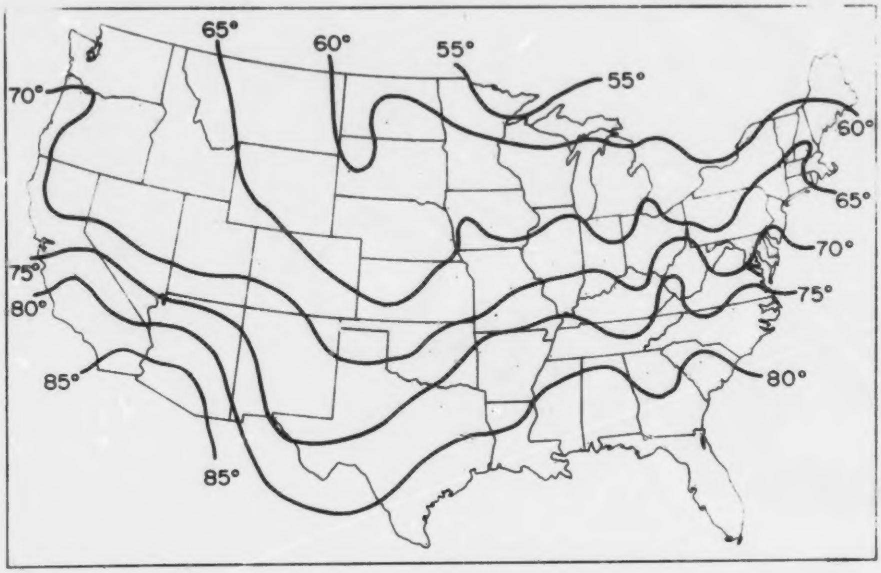

65°
60°
55°
55°
70°
60°
65°
70°
75°
80°
75°
80°
85°
85°

FIGURE 31 - TEMPERATURE, IN °F, OF 3000-ACRE POND ON MAY 1, NORMAL METEOROLOGICAL CONDITIONS

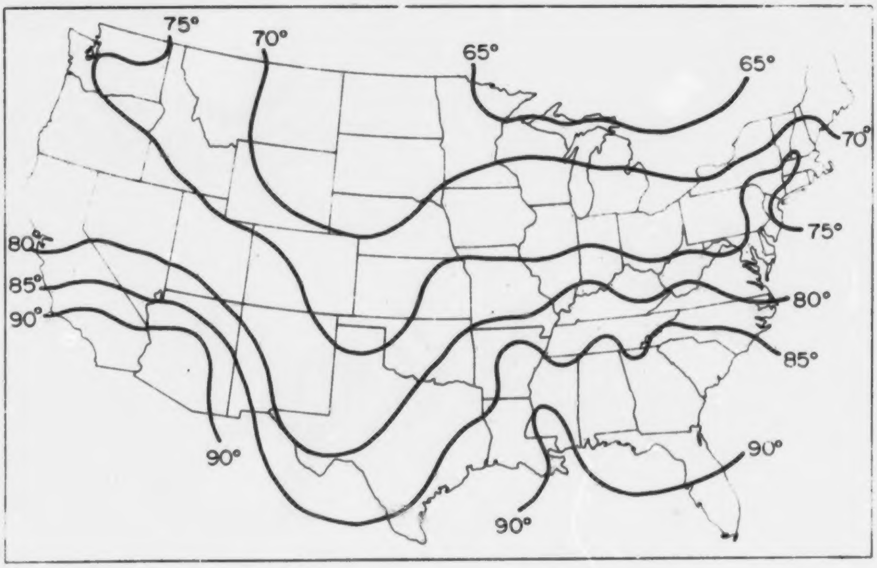
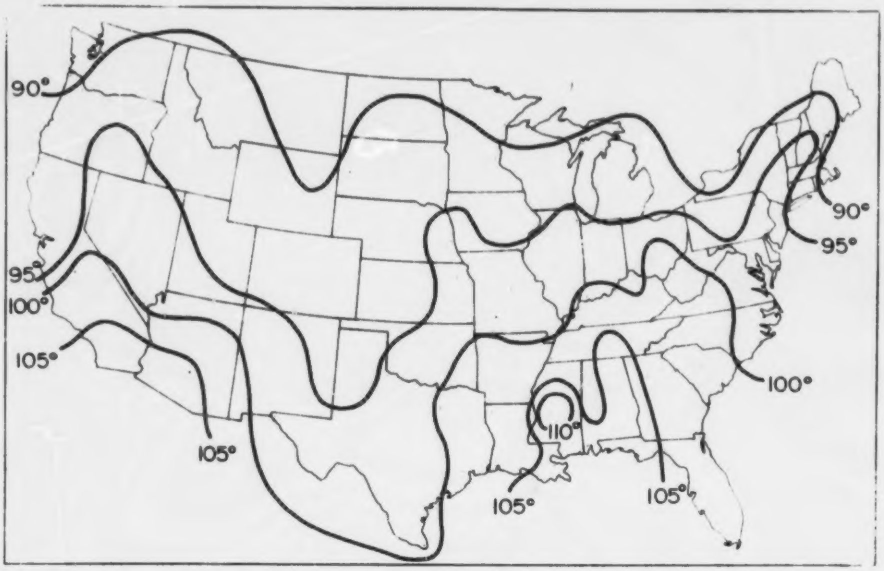
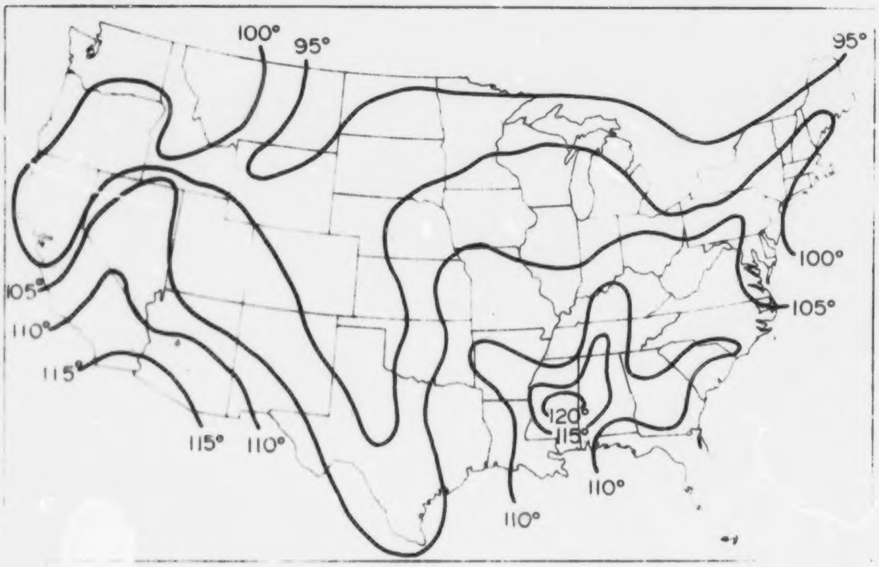

75°
70°
65°
65°
70°
75°
80°
85°
90°
80°
85°
90°
90°
90°

FIGURE 32 - TEMPERATURE, IN °F, OF 3000-ACRE POND ON MAY 1, EXTREME METEOROLOGICAL CONDITIONS



90°
95°
100°
105°
105°
110°
105°
105°
100°
95°
90°

FIGURE 33 - TEMPERATURE, IN °F, OF 1000-ACRE POND ON AUGUST 1, NORMAL METEOROLOGICAL CONDITIONS



100°
95°
95°
105°
110°
115°
115°
110°
110°
120°
115°
110°
100°
105°

FIGURE 34 - TEMPERATURE, IN °F, OF 1000-ACRE POND ON AUGUST 1, EXTREME METEOROLOGICAL CONDITIONS

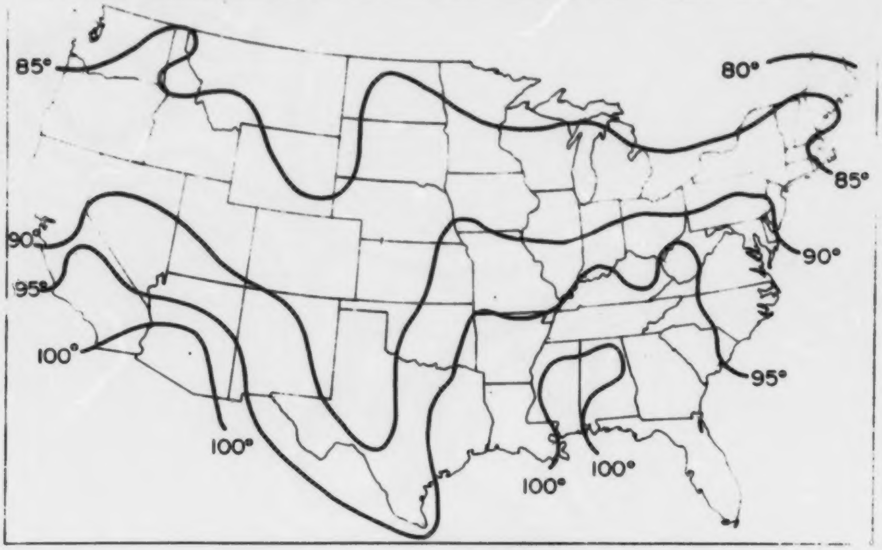

85°
80°
85°
90°
90°
95°
95°
100°
100°
100°
100°

FIGURE 35 - TEMPERATURE, IN °F, OF 2000-ACRE POND ON AUGUST 1, NORMAL METEOROLOGICAL CONDITIONS

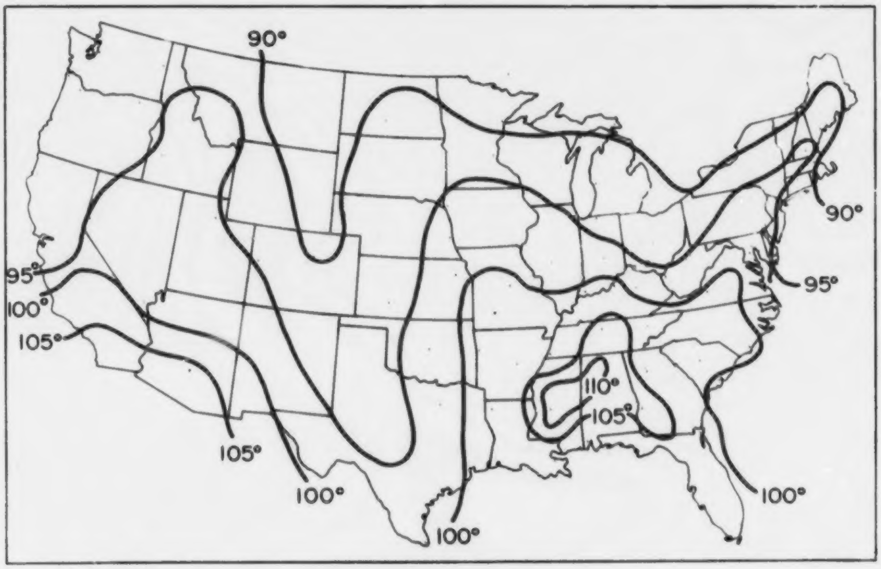

90°
90°
95°
95°
100°
105°
110°
105°
105°
100°
100°
100°

FIGURE 36 - TEMPERATURE, IN °F, OF 2000-ACRE POND ON AUGUST 1, EXTREME METEOROLOGICAL CONDITIONS

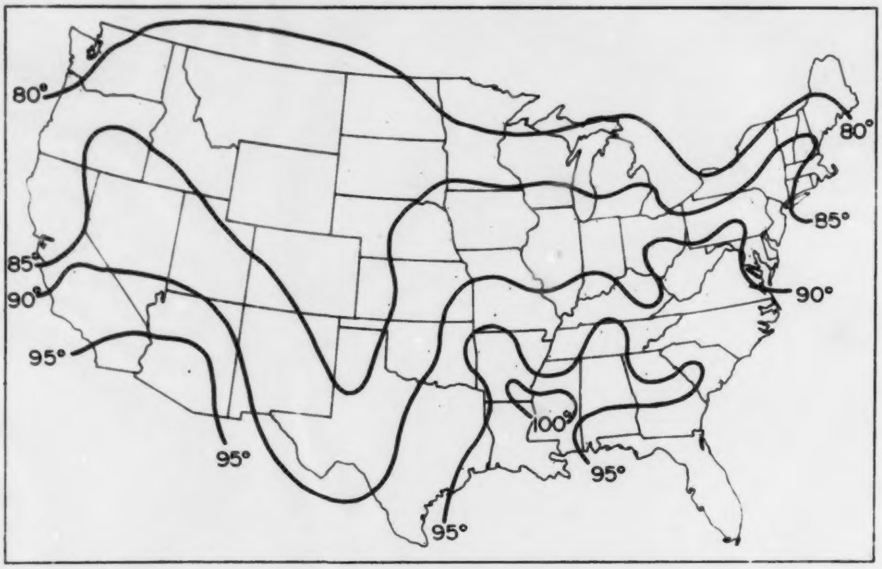

80°
80°
85°
85°
90°
90°
95°
95°
100°
95°
95°

FIGURE 37 - TEMPERATURE, IN °F, OF 3000-ACRE POND ON AUGUST 1, NORMAL METEOROLOGICAL CONDITIONS

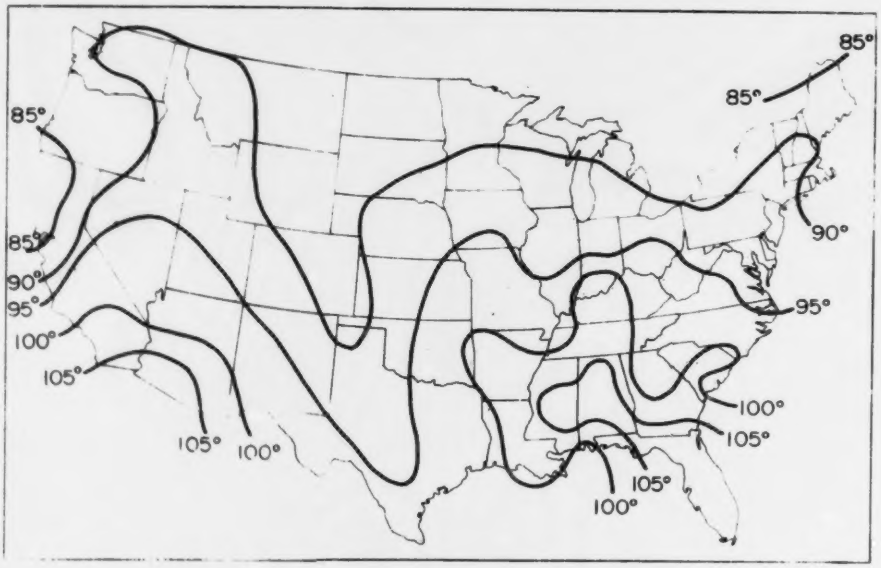

85°
85°
85°
85°
90°
90°
95°
95°
100°
105°
105°
100°
100°
105°
105°
100°

FIGURE 38 - TEMPERATURE, IN °F, OF 3000-ACRE POND ON AUGUST 1, EXTREME METEOROLOGICAL CONDITIONS

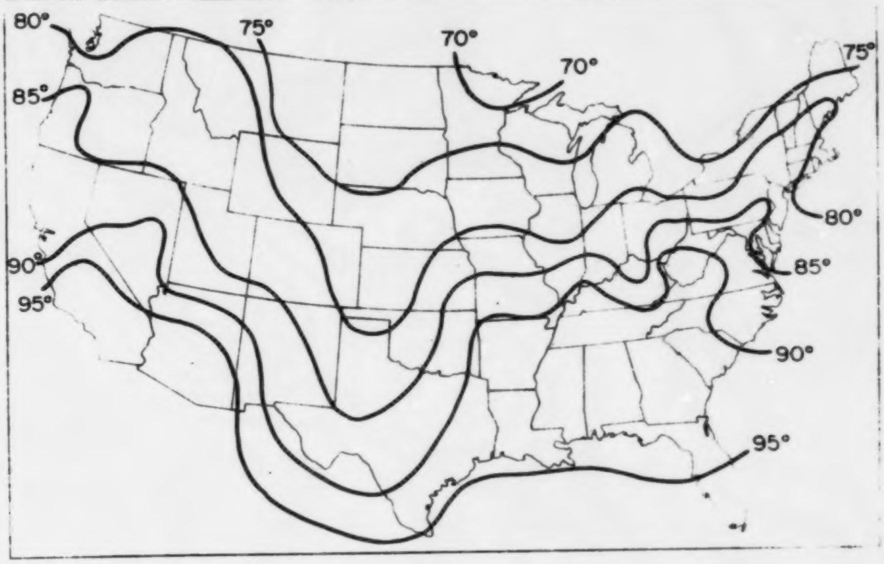

80°
75°
70°
70°
75°
85°
80°
90°
85°
95°
90°
95°

FIGURE 39 - TEMPERATURE, IN °F, OF 1000-ACRE POND ON OCTOBER 1, NORMAL METEOROLOGICAL CONDITIONS

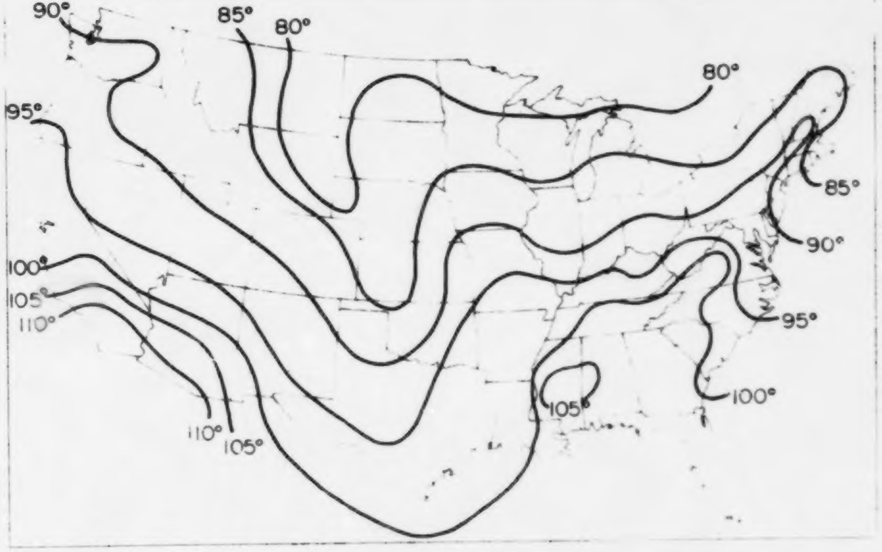

90°
85°
80°
80°
95°
85°
90°
100°
105°
110°
95°
100°
105°
110°
105°

FIGURE 40 - TEMPERATURE, IN °F, OF 1000-ACRE POND ON OCTOBER 1, EXTREME METEOROLOGICAL CONDITIONS

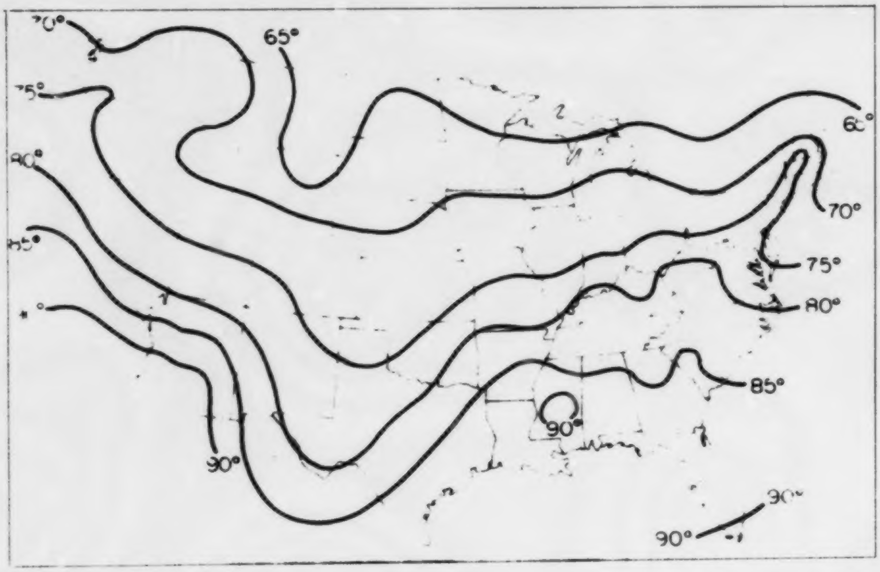

70°
65°
75°
60°
80°
70°
85°
75°
80°
85°
90°
90°
90°
90°

FIGURE 41 - TEMPERATURE, IN °F, OF 2000-ACRE POND ON OCTOBER 1, NORMAL METEOROLOGICAL CONDITIONS

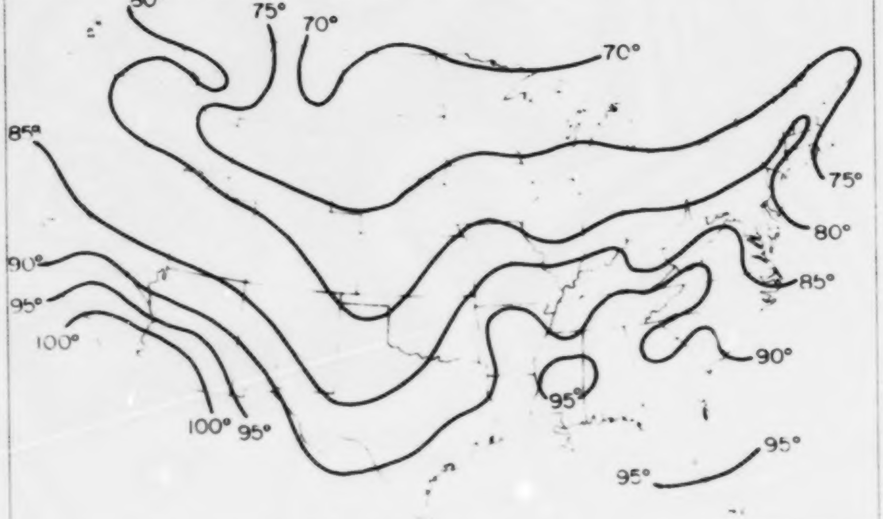

80°
75°
70°
70°
85°
75°
80°
90°
85°
95°
100°
90°
100°
95°
95°
95°
95°

FIGURE 42 - TEMPERATURE, IN °F, OF 2000-ACRE POND ON OCTOBER 1, EXTREME METEOROLOGICAL CONDITIONS

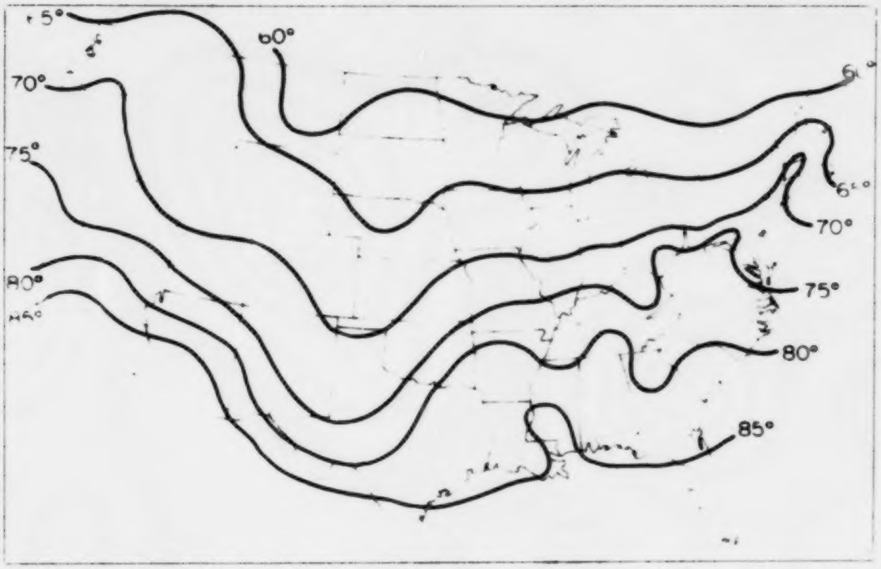

60°
70°
75°
80°
70°
75°
80°
85°

FIGURE 43 - TEMPERATURE, IN °F, OF 3000-ACRE POND ON OCTOBER 1, NORMAL METEOROLOGICAL CONDITIONS

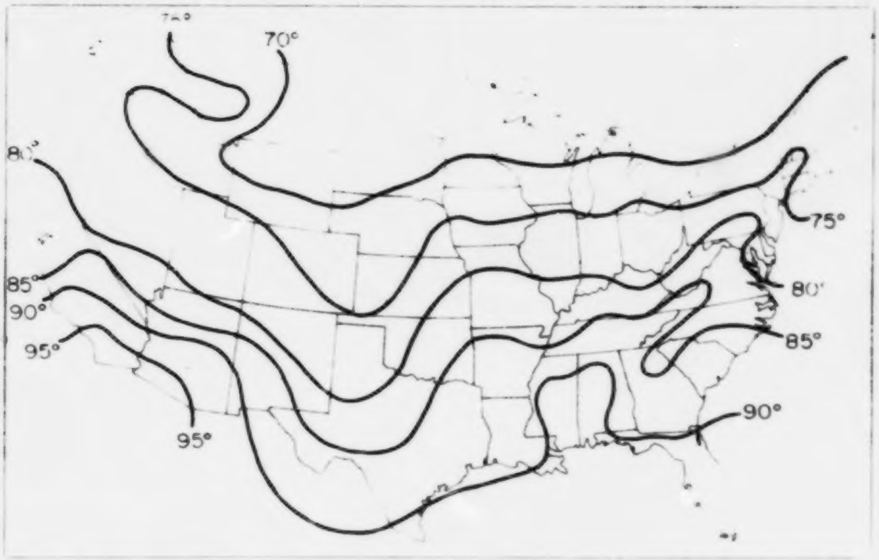

70°
80°
85°
90°
95°
95°
75°
80°
85°
90°

FIGURE 44 - TEMPERATURE, IN °F, OF 3000-ACRE POND ON OCTOBER 1, EXTREME METEOROLOGICAL CONDITIONS

Accuracy of Contour Lines

The contour lines were drawn by hand with due regard to both the numerical values of the plotted points at the various weather stations and the nature of the topography and climate in the area. Awareness of the topography was especially valuable in determining plausible patterns for the lines in areas where the pattern of numerical values seemed confusing.

In most cases, logical patterns could be constructed in which a particular line actually divides the values correctly, with all values above that of the contour on one side and all values below it on the other side. In a few cases, particularly the midwest and upper great plains, this was not feasible. Usually it was because the variation was slight over a large area and the individual values seemed to vary almost randomly in the area. When areal variation is so slight, individual conditions at the site have a relatively greater influence, and the regular variation of the pattern is destroyed.

There were, however, 4 stations which consistently produced values which did not fit the pattern established by the remainder of the stations. Las Vegas, Nevada, consistently produced results which showed considerably more effective cooling than the other stations in the vicinity; while Jackson, Mississippi, Des Moines, Iowa, and Concord, New Hampshire produced cooling which was not as effective. In addition, Fort Smith and Little Rock, Arkansas, sometimes produced results which were not as good as other stations in the vicinity.

Subject to the aforementioned limitations, it is believed that the results presented are reasonably accurate, based on the data from the stations used, and will be of value in preliminary analyses of cooling pond feasibility. It should always be recognized, however, that local topographic and meteorological conditions can exert a great influence on pond requirements and performance. Thus, before any pond is actually sized or built, a more thorough study, using meteorological data from the actual site or from close by, should be conducted.

RELATION OF COMPLETELY MIXED POND TO PLUG FLOW POND

All calculations for this project have been performed assuming completely mixed ponds. The basic assumption of completely mixed flow is that the pond temperature is uniform throughout, and that anything (such as heat, or a pollutant, or a tracer) added to the pond is "instantaneously" dispersed uniformly throughout the pond. It would be impossible for a real pond of significant size to behave exactly in this manner. However, it is possible for ponds to approach this condition so that the theoretical and actual dynamic behavior, measured at the outlet, differs by a negligible amount. In such a pond, the condenser water temperature would drop to the uniform pond temperature in a relatively short time, and only a small fraction of the pond volume around the plant outfall would have a temperature higher than the mixed temperature. Conditions conducive to such behavior would include sufficient depth to allow flow to circulate easily in the pond due to the influence of plant discharge and wind, but not so deep as to allow stratification; a surface shape approaching the circular, so the influent can mix easily into all parts of the pond; a discharge located away from the pond shore; and a long detention time.

The other extreme hydraulic condition, exactly opposite to complete mixing, is plug flow. Plug flow implies no mixing at all. Each parcel of influent follows the same path through the pond, utilizes the entire cross-sectional flow area, does not mix with the parcels ahead or behind, and arrives at the outlet in sequence at the exact volumetric detention time. This type of flow is much more difficult to approach in the field than is completely mixed flow, but reasonable approximations can be realized. Conditions which encourage plug flow are long slender channel-like ponds, with the outlet at the opposite end from the inlet, narrow width to decrease wind mixing, high width-to-depth ratios to reduce lateral velocity gradients, and shallow depth and low velocity to reduce vertical velocity gradients. (These conditions are not always mutually consistent, which is part of the problem.)

The plug-flow pond is more expensive to build but provides quicker cooling. This is because the hot water is not initially mixed or diluted with any cooler water, and the driving force for cooling, $T_w - T_e$, is maintained at the highest possible value.

Edinger and Geyer (3) show how the area required by each type of pond for a given amount of cooling can be calculated, based on the two solutions for the linear approximation to the heat transfer process (Equation 1). The solution of Equation 1 for a completely mixed pond is

$$\frac{T_m - T_e}{T_o - T_e} = \frac{1}{1 + r} \qquad (18)$$

where T_m = the mixed pond temperature (effluent temperature); T_o = the pond influent temperature (condenser discharge); T_e = the equilibrium temperature; and in which

$$r = \frac{KA}{\rho c_p Q} \tag{19}$$

where A = the pond surface area; ρ = the water density; c_p = the specific heat of water; and Q = the flowrate through the pond (plant pumpage).

The solution of Equation 1 for a plug-flow pond is

$$\frac{T_p - T_e}{T_o - T_e} = e^{-r} \tag{20}$$

in which T_p is the pond effluent temperature at the end of a plug-flow pond of surface area A.

The ratio of the net plant temperature rise at the end of a completely mixed pond to that at the end of a plug-flow pond is calculated by dividing Equation 18 by Equation 20. The result is

$$\frac{T_m - T_e}{T_p - T_e} = \frac{e^r}{1 + r} \tag{21}$$

The area of a plug-flow pond necessary to produce the same cooling as a completely mixed pond ($T_m - T_e = T_p - T_e$) is given by the relation

$$r_m = e^{r_p} - 1 \tag{22}$$

where the only difference between r_m and r_p is the surface area A. Table 3,

TABLE 3 - RATIO OF AREA REQUIRED BY PLUG-FLOW POND TO THAT REQUIRED BY COMPLETELY MIXED POND TO PRODUCE EQUIVALENT COOLING UNDER SAME CONDITIONS

Temperature Excess Ratio $\left(\frac{T - T_e}{T_o - T_e}\right)$	$T - T_e$ $\left(\begin{matrix}\text{For } T_o - T_e \\ \text{of } 15°\end{matrix}\right)$	Area Ratio $\left(\frac{A_p}{A_m}\right)$
0.8	12.0°	0.89
0.7	10.5°	0.83
0.6	9.0°	0.77
0.5	7.5°	0.69
0.4	6.0°	0.61
0.3	4.5°	0.51
0.2	3.0°	0.40
0.1	1.5°	0.26

adapted from Edinger and Geyer, shows the area ratio required for various values of the excess of pond effluent temperature over equilibrium temperature.

Using Table 3, any of the areas determined for a completely mixed pond can be converted to the area of an equivalent plug-flow pond. It should be noted, however, that true plug-flow is impossible to attain on such a large scale, due to the inability to eliminate longitudinal mixing in large bodies of water. If a plug-flow type pond is desired, the area required will be somewhat more than that for a perfect plug-flow pond, but less than that required for a completely mixed pond. The behavior of almost all real ponds lies somewhere between the two extremes, depending on pond characteristics. However, the results presented in this report will allow rapid determination of the upper and lower limits of required area. Further study would then be required to complete design of an appropriate pond for a given situation.

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APPENDIX A

WEATHER INFORMATION FOR INDIVIDUAL STATIONS

TABLE 4

WEATHER INFORMATION FOR Huntsville, Alabama

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND
JAN	6.6	42.9	.72		8.4					
FEB	6.7	45.1	.69		9.4					
MAR	6.2	51.8	.64		9.5					
APR	5.9	61.6	.62		8.8					
MAY	5.7	70.4	.66		6.6					
JUNE	5.9	78.6	.69		6.1					
JULY	6.0	81.1	.71		5.5					
AUG	5.7	80.2	.73		5.5					
SEPT	5.3	74.5	.71		6.7					
OCT	4.3	63.2	.68		6.5					
NOV	6.1	50.8	.70		7.6					
DEC	6.7	43.6	.72		8.4					

LATITUDE = 34° 39' N

LONGITUDE = 86° 46' W

ELEVATION = 624 ft.

TABLE 5

WEATHER INFORMATION FOR Mobile, Alabama (13894)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.5	53.0	.74		11.1	4.2	58.0	.80		7.6
FEB	6.4	55.2	.66		11.6	4.0	60.0	.79		8.2
MAR	6.0	60.3	.70		11.5	4.4	63.0	.745		7.8
APR	5.8	67.6	.74		10.9	3.7	69.8	.748		7.9
MAY	5.6	75.6	.72		9.3	3.0	76.0	.76		6.9
JUNE	5.8	81.5	.74		8.0	3.5	81.0	.78		5.2
JULY	6.7	82.6	.74		7.2	5.0	81.2	.83		5.1
AUG	5.9	82.1	.78		7.1	4.0	81.5	.805		4.5
SEPT	5.8	77.9	.74		8.5	4.0	77.5	.80		5.0
OCT	4.2	69.9	.70		8.7	1.5	69.8	.78		5.9
NOV	5.2	58.9	.73		10.0	3.0	60.0	.76		6.8
DEC	6.2	54.1	.74		10.6	4.2	56.0	.785		7.8

LATITUDE = 30° 41.0' N

LONGITUDE = 88° 14.5' W

ELEVATION = 211 ft.

*Extreme conditions given in knots

TABLE 6

WEATHER INFORMATION FOR Phoenix, Arizona

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	4.8	49.7	.50		4.8	1.5	53.5	.66		2.7
FEB	4.4	53.5	.45		5.3	2.0	60.0	.60		3.2
MAR	4.4	59.0	.41		6.0	2.2	63.0	.545		4.45
APR	3.6	67.2	.30		6.3	1.0	72.7	.44		4.2
MAY	2.8	75.0	.23		6.4	1.2	81.5	.29		4.6
JUNE	1.9	83.6	.23		6.4	0.0	90.0	.28		4.6
JULY	3.8	89.8	.34		6.6	1.7	93.3	.43		4.7
AUG	3.4	87.5	.41		6.1	1.3	91.0	.485		4.07
SEPT	2.1	82.8	.40		5.8	0.3	85.6	.46		3.9
OCT	2.6	70.7	.36		5.2	1.0	75.8	.49		3.3
NOV	3.5	58.1	.47		4.8	1.3	62.5	.58		3.2
DEC	3.8	51.6	.54		4.7	1.3	54.3	.64		2.8

LATITUDE = 33° 26' N

LONGITUDE = 112° 01' W

ELEVATION = 1117 ft.

*Extreme conditions given in knots

TABLE 7

WEATHER INFORMATION FOR Fort Smith, Arkansas (13964)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.5	39.8	.69		8.2	4.0	43.0	.76		6.0
FEB	6.1	43.7	.63		8.4	4.2	48.0	.74		6.7
MAR	6.1	51.1	.62		9.5	4.0	55.0	.68		7.35
APR	6.0	61.7	.65		8.9	4.2	65.5	.66		6.8
MAY	6.0	69.9	.70		8.0	4.0	73.0	.73		5.9
JUNE	5.4	78.6	.70		6.8	3.0	80.0	.75		5.0
JULY	5.4	83.0	.70		6.5	3.0	83.7	.75		5.0
AUG	4.8	82.3	.70		6.6	2.5	82.0	.755		4.8
SEPT	4.6	74.9	.68		6.8	2.0	75.5	.78		4.8
OCT	4.4	63.8	.64		6.8	2.0	66.5	.77		5.2
NOV	5.2	50.0	.68		7.7	3.0	53.0	.74		5.4
DEC	6.0	42.3	.70		8.1	4.0	44.5	.74		5.93

LATITUDE = 35° 20' N

LONGITUDE = 94° 22' W

ELEVATION = 447 ft.

*Extreme conditions given in knots

TABLE 8

WEATHER INFORMATION FOR Little Rock, Arkansas (13963)

	MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
DAY		CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
15	JAN	6.9	41.8	.72		9.1	4	47	.78		6.83
45	FEB	6.3	45.6	.69		9.4	4.2	49	.745		6.75
74	MAR	6.3	52.8	.66		10.2	4	57	.69		7.8
105	APR	6.0	62.5	.66		9.8	4.2	66.5	.675		7.3
135	MAY	6.1	69.8	.70		8.4	3.5	73.5	.74		5.7
166	JUNE	5.3	78.5	.71		7.9	3	82	.76		5.2
196	JULY	5.5	81.9	.71		7.3	3.7	83	.775		5.0
227	AUG	4.9	81.3	.70		6.9	3	82	.747		4.5
258	SEPT	4.6	74.8	.70		7.2	2	76	.77		5.1
288	OCT	4.4	64.1	.70		7.0	2	65.5	.75		4.95
319	NOV	5.2	51.5	.68		8.4	3.2	54	.723		6.2
349	DEC	6.3	43.9	.72		8.5	4.2	48	.74		6.2

LATITUDE = 34° 44' N

LONGITUDE = 92° 14' N

ELEVATION = 257 ft.

*Extreme conditions given in knots

TABLE 9

WEATHER INFORMATION FOR Burbank, California (23152)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	5.2	53.6	.59		4.3	2.2	56.2	.666		2.68
FEB	5.0	55.2	.60		4.9	2.3	59.2	.697		2.78
MAR	5.0	57.9	.60		5.4	2.5	59.2	.662		3.58
APR	5.1	61.2	.63		5.7	2.8	63.4	.702		3.68
MAY	4.7	64.4	.64		5.6	2.4	65.1	.692		3.28
JUNE	3.7	68.0	.66		5.6	1.9	69.2	.696		3.29
JULY	2.5	73.8	.62		5.7	0.8	74.8	.663		3.47
AUG	2.4	74.1	.62		5.3	1.1	74.3	.672		3.16
SEPT	2.5	72.6	.60		4.6	0.8	74.4	.666		2.64
OCT	3.8	66.3	.62		4.3	1.6	69.3	.682		2.74
NOV	4.0	60.4	.54		4.1	1.8	61.8	.608		2.17
DEC	4.2	55.6	.54		4.1	1.6	57.2	.653		2.27

LATITUDE = 34° 12' N

LONGITUDE = 118° 22' W

ELEVATION = 724 ft.

*Extreme conditions given in knots

TABLE 10

WEATHER INFORMATION FOR Fresno, California (93193)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	7.1	45.5	.84		5.4	4.0	47.5	.88		3.7
FEB	5.9	49.8	.77		5.8	2.5	54.0	.828		3.82
MAR	5.1	54.4	.67		6.7	2.7	55.5	.733		4.9
APR	4.3	60.8	.58		6.9	1.5	64.5	.66		5.4
MAY	3.5	67.5	.51		7.9	1.5	69.7	.56		5.7
JUNE	1.5	73.9	.44		8.0	0.3	78.0	.49		6.53
JULY	1.0	80.6	.40		7.0	0.0	82.8	.44		5.4
AUG	1.1	78.4	.44		6.4	0.1	82.0	.48		4.6
SEPT	1.5	73.9	.50		5.8	0.0	75.0	.54		4.3
OCT	2.7	64.3	.55		5.3	0.4	67.0	.65		3.95
NOV	4.7	53.2	.69		4.7	1.4	55.7	.831		2.99
DEC	6.9	46.4	.82		4.8	4.0	49.0	.89		3.2

LATITUDE = 36° 46' N

LONGITUDE = 119° 43' W

ELEVATION = 328 ft.

*Extreme conditions given in knots

TABLE 11

WEATHER INFORMATION FOR Oakland, California (23230)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.2	48.0	.77		6.2	2.5	50.0	.82		4.4
FEB	6.0	50.7	.75		7.0	3.0	54.5	.81		4.2
MAR	5.7	53.6	.72		8.7	3.2	54.5	.735		6.1
APR	5.2	56.6	.72		9.2	3.0	57.7	.735		6.15
MAY	5.0	59.7	.72		9.8	3.0	59.0	.725		6.7
JUNE	3.8	62.8	.72		9.8	2.2	63.5	.75		7.4
JULY	3.6	64.3	.75		9.0	1.5	63.3	.768		6.4
AUG	4.0	64.2	.76		8.9	2.2	64.0	.78		6.1
SEPT	3.4	65.1	.73		7.5	2.0	64.8	.76		5.0
OCT	4.4	61.1	.73		6.6	2.3	62.5	.76		4.3
NOV	5.7	54.7	.73		5.7	2.7	57.0	.795		3.8
DEC	6.1	49.5	.78		5.6	4.0	52.3	.815		3.5

LATITUDE = 37° 44' N

LONGITUDE = 122° 12' W

ELEVATION = 10 ft.

*Extreme conditions given in knots

TABLE 12

WEATHER INFORMATION FOR Denver, Colorado (23062)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	5.3	28.7	.54		9.9	3.5	34.5	.58		6.5
FEB	5.8	32.0	.55		10.2	4.1	38.0	.62		6.6
MAR	5.9	37.8	.52		10.8	4.0	42.0	.64		7.5
APR	6.4	47.5	.51		11.0	4.3	50.7	.56		7.85
MAY	6.3	56.3	.54		10.1	4.2	60.5	.59		7.4
JUNE	4.8	66.4	.48		10.0	3.2	71.0	.59		6.7
JULY	4.9	72.8	.47		9.1	3.7	75.3	.54		6.6
AUG	4.8	71.3	.47		8.7	3.2	72.5	.53		6.43
SEPT	4.0	62.7	.45		8.7	2.4	65.0	.58		6.5
OCT	4.4	51.5	.47		8.6	2.3	56.0	.53		6.4
NOV	5.1	39.3	.50		9.7	3.3	43.0	.61		6.05
DEC	5.0	31.7	.51		9.9	3.2	35.0	.59		6.6

LATITUDE = 39° 46' N

LONGITUDE = 104° 53' W

ELEVATION = 5292 ft.

*Extreme conditions given in knots

TABLE 13

WEATHER INFORMATION FOR Grand Junction, Colorado (23066)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.0	26.0	.68		5.6	4.2	32.0	.76		3.5
FEB	6.4	32.6	.62		6.7	3.7	38.0	.71		3.85
MAR	6.1	41.5	.50		8.4	4.0	43.0	.61		5.37
APR	5.9	52.3	.38		9.7	4.2	55.0	.46		5.8
MAY	5.5	62.2	.33		10.0	3.5	65.5	.42		6.6
JUNE	3.7	71.3	.26		10.2	1.7	75.7	.38		7.1
JULY	4.0	78.2	.31		9.5	3.1	80.0	.39		6.2
AUG	4.4	75.5	.37		9.0	2.5	76.5	.47		6.2
SEPT	3.4	67.8	.36		9.1	1.4	69.0	.46		6.3
OCT	3.9	55.0	.42		8.2	2.0	58.0	.52		5.0
NOV	5.0	38.8	.57		6.7	2.7	42.8	.63		4.6
DEC	5.6	29.1	.66		5.8	3.3	34.3	.75		3.4

LATITUDE = 39° 07' N

LONGITUDE = 108° 32' W

ELEVATION = 4825 ft.

*Extreme conditions given in knots

TABLE 14

WEATHER INFORMATION FOR Hartford, Connecticut

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND
JAN	6.3	26.0	.66		9.9					
FEB	6.6	27.1	.66		10.0					
MAR	6.6	36.0	.66		10.4					
APR	6.8	48.5	.59		10.7					
MAY	6.6	59.9	.62		9.7					
JUNE	6.6	68.7	.68		8.5					
JULY	6.5	73.4	.68		7.8					
AUG	6.4	71.2	.72		7.8					
SEPT	5.9	63.3	.75		8.0					
OCT	5.9	53.0	.70		8.5					
NOV	6.9	41.3	.70		9.1					
DEC	6.6	28.9	.72		9.1					

LATITUDE = 41° 56' N

LONGITUDE = 72° 41' W

ELEVATION = 169 ft.

TABLE 15

WEATHER INFORMATION FOR Wilmington, Delaware (13781)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.6	33.4	.70		9.7	4.0	38.0	.73		7.0
FEB	6.4	33.8	.69		10.3	4.7	38.0	.755		7.6
MAR	6.3	41.3	.67		11.1	4.4	43.5	.70		8.5
APR	6.6	52.1	.66		10.4	5.1	54.7	.68		8.0
MAY	6.6	62.7	.68		8.9	5.2	64.5	.74		6.4
JUNE	5.8	71.4	.70		8.3	4.3	72.5	.725		6.2
JULY	6.0	76.0	.71		7.6	4.2	77.5	.77		5.5
AUG	5.8	74.3	.74		7.4	4.0	76.0	.777		5.1
SEPT	5.5	67.6	.74		8.0	3.3	69.0	.78		5.5
OCT	5.2	56.6	.73		8.1	3.0	58.8	.75		5.8
NOV	6.2	45.4	.72		9.0	4.0	47.0	.733		6.4
DEC	6.3	35.1	.71		9.1	4.4	38.0	.755		6.65

LATITUDE = 39° 40'N

LONGITUDE = 75° 36'W

ELEVATION = 78 ft.

*Extreme conditions given in knots

TABLE 16

WEATHER INFORMATION FOR Washington, D. C. (13743)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.8	36.2	.66		10.8	4.2	41.0	.68		7.35
FEB	6.4	37.1	.62		11.1	4.3	42.0	.70		7.4
MAR	6.1	45.3	.60		12.0	4.3	47.0	.625		7.9
APR	6.5	54.4	.60		11.3	5.1	58.0	.635		7.8
MAY	6.4	64.7	.66		9.8	4.3	68.0	.68		7.0
JUNE	5.6	73.4	.67		9.4	4.1	75.6	.70		6.4
JULY	5.9	77.3	.68		8.6	4.0	80.0	.717		6.4
AUG	5.6	75.4	.71		8.4	4.0	78.0	.74		6.2
SEPT	5.4	69.6	.72		8.7	3.2	72.5	.745		6.03
OCT	5.3	58.2	.71		9.2	2.0	61.7	.72		6.4
NOV	5.9	47.7	.66		9.6	4.0	49.5	.68		6.8
DEC	6.2	38.0	.64		9.7	4.4	41.7	.69		7.0

LATITUDE = 38° 51' N

LONGITUDE = 77° 02' W

ELEVATION = 14 ft.

*Extreme conditions given in knots

TABLE 17

WEATHER INFORMATION FOR Jacksonville, Florida (93837)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	5.9	55.9	.75		8.6	4.2	60.0	.775		5.6
FEB	5.8	57.5	.72		9.9	4.0	63.5	.76		6.2
MAR	5.8	62.2	.70		9.8	4.3	65.0	.70		6.1
APR	5.3	68.7	.69		9.5	4.0	70.7	.74		6.45
MAY	5.3	75.8	.70		9.0	4.1	77.5	.75		6.1
JUNE	6.2	80.8	.74		8.8	5.1	81.5	.78		5.8
JULY	6.4	82.6	.77		8.0	5.3	82.7	.795		5.4
AUG	6.1	82.3	.79		7.7	4.7	83.0	.82		5.1
SEPT	6.7	79.4	.80		9.0	5.4	79.8	.825		5.2
OCT	5.4	71.0	.78		9.0	3.5	74.0	.815		6.0
NOV	5.1	61.7	.76		8.6	3.0	65.5	.785		5.6
DEC	5.9	56.1	.76		8.3	4.2	60.3	.80		5.3

LATITUDE = 30° 25' N

LONGITUDE = 81° 39' W

ELEVATION = 20 ft.

*Extreme conditions given in knots

TABLE 18

WEATHER INFORMATION FOR Miami, Florida (12839)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	4.9	66.9	.75		9.2	3.0	70.0	.75		6.6
FEB	5.0	67.9	.74		9.8	3.2	72.0	.745		7.0
MAR	5.1	70.5	.72		10.1	3.2	73.3	.737		7.7
APR	5.5	74.2	.71		10.5	4.0	75.8	.73		7.6
MAY	5.5	77.6	.74		9.1	3.2	78.7	.79		6.75
JUNE	6.6	80.8	.77		8.0	4.7	80.8	.80		5.6
JULY	6.4	81.8	.77		7.9	5.0	82.5	.785		5.5
AUG	6.4	82.3	.78		7.3	5.0	82.8	.79		5.1
SEPT	6.6	81.3	.80		8.1	5.1	81.8	.82		5.0
OCT	6.0	77.8	.78		9.0	4.2	78.0	.805		5.9
NOV	5.2	72.4	.76		9.0	3.3	74.0	.77		6.6
DEC	5.3	68.1	.76		8.4	2.5	71.0	.77		6.2

LATITUDE = 25° 48' N

LONGITUDE = 80° 16' W

ELEVATION = 7 ft.

*Extreme conditions given in knots

TABLE 19

WEATHER INFORMATION FOR Tampa, Florida (12842)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	5.2	61.2	.76		9.0	3.0	64.0	.76		5.8
FEB	5.2	62.7	.75		9.6	3.5	66.0	.765		6.5
MAR	5.4	66.0	.74		10.1	3.5	68.0	.745		7.4
APR	5.2	71.4	.71		9.9	3.0	72.7	.73		7.1
MAY	4.9	76.8	.72		9.1	3.0	77.7	.74		6.4
JUNE	6.0	80.6	.75		8.4	4.5	81.3	.78		6.1
JULY	6.7	81.6	.78		7.7	5.1	81.5	.79		5.4
AUG	6.7	82.0	.80		7.4	5.1	81.5	.803		5.63
SEPT	6.5	80.5	.80		8.6	4.7	80.0	.808		5.3
OCT	5.1	74.7	.77		9.0	25.0	75.7	.78		6.0
NOV	4.9	66.8	.76		9.1	2.3	69.0	.763		6.2
DEC	5.5	62.3	.76		9.2	3.5	64.3	.775		6.65

LATITUDE = 27° 58' N

LONGITUDE = 82° 32' W

ELEVATION = 19 ft.

*Extreme conditions given in knots

TABLE 20

WEATHER INFORMATION FOR Atlanta, Georgia (13874)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.4	44.6	.73		11.3	5.0	50.0	.76		7.0
FEB	6.2	46.7	.68		11.7	4.0	51.5	.70		7.85
MAR	6.1	52.7	.66		11.8	4.7	55.0	.69		7.3
APR	5.5	61.7	.63		10.8	4.0	64.0	.687		7.0
MAY	5.4	70.0	.66		9.0	3.0	72.0	.72		5.8
JUNE	5.8	77.7	.70		8.3	4.0	77.6	.771		5.46
JULY	6.3	79.5	.76		7.7	4.5	80.0	.791		5.03
AUG	5.7	78.5	.72		7.4	3.5	79.1	.781		5.03
SEPT	5.3	74.4	.73		8.4	3.6	74.1	.77		5.49
OCT	4.5	63.4	.72		8.7	0.9	64.7	.761		5.59
NOV	5.1	51.9	.67		9.6	3.0	53.1	.721		6.1
DEC	6.2	45.2	.70		10.3	4.3	46.6	.751		6.79

LATITUDE = 33° 39' N

LONGITUDE = 84° 25' W

ELEVATION = 975 ft.

*Extreme conditions given in knots

TABLE 21

WEATHER INFORMATION FOR Boise, Idaho (24131)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	7.6	29.1	.80		8.6	6.2	36.0	.81		5.5
FEB	7.1	34.5	.74		9.4	5.2	40.5	.78		6.6
MAR	6.7	41.7	.61		10.5	4.0	43.5	.68		7.5
APR	6.3	50.4	.54		10.2	4.0	52.0	.63		7.4
MAY	5.8	58.2	.54		9.5	4.0	61.5	.62		6.8
JUNE	4.8	65.8	.50		9.1	2.3	68.5	.59		6.4
JULY	2.5	75.2	.37		8.5	1.0	78.0	.41		5.9
AUG	3.2	72.1	.38		8.3	1.3	76.0	.43		5.8
SEPT	3.5	62.7	.45		8.3	1.2	67.0	.49		6.0
OCT	5.0	51.6	.55		8.7	2.3	56.0	.66		5.9
NOV	6.8	38.6	.72		8.6	4.0	43.5	.76		6.2
DEC	7.6	32.2	.79		8.4	5.5	35.0	.83		4.0

LATITUDE = 43° 34' N

LONGITUDE = 116° 13' W

ELEVATION = 2838 ft.

*Extreme conditions given in knots

TABLE 22

WEATHER INFORMATION FOR Chicago, Illinois (14819)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	7.0	26.0	.68		11.4	5.3	29.0	.773		8.9
FEB	6.7	27.7	.64		11.6	5.0	33.0	.758		8.2
MAR	7.0	36.3	.64		11.8	5.5	40.0	.70		9.1
APR	6.8	49.0	.64		11.7	4.7	52.5	.685		8.6
MAY	6.3	60.0	.60		10.4	4.3	65.5	.655		8.0
JUNE	6.0	70.5	.62		9.2	4.3	73.7	.663		6.7
JULY	5.3	75.6	.65		8.2	4.0	77.5	.68		6.1
AUG	5.3	74.2	.67		8.0	3.5	76.0	.705		5.6
SEPT	5.3	66.1	.66		8.9	3.2	68.7	.70		6.7
OCT	5.2	55.1	.62		9.8	3.0	59.0	.70		7.2
NOV	7.0	39.9	.69		11.4	5.1	43.5	.707		8.8
DEC	7.0	29.1	.75		11.2	5.0	35.0	.78		8.45

LATITUDE = 41° 47' N

LONGITUDE = 87° 45' W

ELEVATION = 607 ft.

*Extreme conditions given in knots

TABLE 23

WEATHER INFORMATION FOR Springfield, Illinois (93822)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	7.2	27.4	.76		13.4	5.1	31.0	.795		10.05
FEB	6.5	30.8	.75		13.6	4.5	35.5	.78		9.7
MAR	6.7	40.2	.71		14.8	5.1	43.0	.76		10.8
APR	6.6	51.7	.66		14.1	4.5	57.0	.71		10.5
MAY	6.3	62.0	.66		12.0	4.5	70.0	.70		9.5
JUNE	6.0	71.9	.68		10.2	4.0	77.0	.72		7.8
JULY	5.6	76.3	.71		8.8	4.1	79.3	.75		6.35
AUG	5.1	74.0	.72		8.1	3.2	76.0	.765		5.65
SEPT	4.5	66.9	.67		9.8	2.4	70.0	.74		6.9
OCT	4.7	55.9	.67		10.8	2.0	61.0	.74		8.2
NOV	6.1	40.9	.70		14.2	4.2	45.0	.74		9.2
DEC	6.9	30.6	.76		13.4	4.3	36.5	.815		9.7

LATITUDE = 39° 50' N
LONGITUDE = 89° 40' W
ELEVATION = 589 ft.

*Extreme conditions given in knots

TABLE 24

WEATHER INFORMATION FOR Evansville, Indiana (93817)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	7.3	34.7	.77		10.0	4.7	38.5	.80		6.2
FEB	6.8	37.5	.72		10.3	4.7	40.0	.77		6.6
MAR	6.6	46.6	.69		10.9	5.1	48.5	.72		7.65
APR	6.5	57.1	.67		10.5	5.1	59.7	.695		7.2
MAY	6.4	65.5	.70		8.5	4.3	69.0	.71		6.0
JUNE	5.9	74.6	.70		7.7	4.1	79.0	.745		5.0
JULY	5.6	78.2	.71		6.7	4.0	80.0	.755		4.8
AUG	5.1	76.3	.73		6.1	2.7	77.3	.775		4.6
SEPT	4.7	70.5	.72		7.1	2.3	71.3	.79		5.23
OCT	4.8	59.3	.72		7.3	1.5	61.0	.747		5.5
NOV	6.1	46.0	.72		9.3	4.0	47.0	.76		5.6
DEC	6.9	36.9	.76		9.3	4.5	41.0	.78		6.6

LATITUDE = 38° 03' N

LONGITUDE = 87° 32' W

ELEVATION = 381 ft.

*Extreme conditions given in knots

TABLE 26

WEATHER INFORMATION FOR South Bend, Indiana (14848)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	8.1	25.6	.80		11.8	6.3	29.6	.82		8.79
FEB	7.9	26.8	.78		12.0	6.1	31.0	.805		8.8
MAR	7.5	34.8	.74		12.8	6.1	38.5	.78		9.6
APR	6.9	47.5	.72		12.3	4.5	51.0	.76		9.7
MAY	6.4	58.7	.68		11.2	5.0	63.7	.71		8.7
JUNE	6.1	69.0	.70		9.4	4.3	71.8	.72		7.1
JULY	5.5	73.6	.71		8.4	4.0	75.0	.735		6.4
AUG	5.4	72.0	.73		8.2	4.0	73.0	.77		6.4
SEPT	5.3	63.8	.72		9.3	3.4	66.5	.757		6.65
OCT	5.5	53.4	.74		9.9	3.0	57.0	.78		7.0
NOV	7.6	39.1	.76		11.9	6.0	42.7	.78		8.2
DEC	7.8	28.7	.80		11.8	6.5	33.7	.833		8.4

LATITUDE = 41° 42' N

LONGITUDE = 86° 19' W

ELEVATION = 773 ft.

*Extreme conditions given in knots

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TABLE 27

WEATHER INFORMATION FOR Des Moines, Iowa (14933)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.8	22.1	.76		12.3	5.1	24.0	.82		8.8
FEB	6.4	26.0	.76		12.5	4.4	31.0	.80		8.2
MAR	7.1	37.0	.72		14.2	5.0	39.7	.79		9.4
APR	6.8	50.4	.64		14.5	4.5	52.0	.73		9.0
MAY	6.6	61.2	.67		12.4	5.0	65.0	.71		8.83
JUNE	6.0	70.6	.71		11.3	4.3	74.0	.74		7.2
JULY	5.5	76.2	.68		9.5	3.7	78.5	.74		5.8
AUG	5.3	73.8	.72		9.2	3.3	76.0	.78		5.8
SEPT	4.8	65.8	.68		10.4	3.0	66.0	.80		6.3
OCT	4.9	54.5	.65		11.3	2.7	59.0	.725		7.9
NOV	6.2	38.4	.72		13.4	4.2	41.8	.76		8.3
DEC	6.9	26.2	.76		12.6	4.3	32.0	.81		8.7

LATITUDE = 41° 32' N

LONGITUDE = 93° 39' W

ELEVATION = 948 ft.

*Extreme conditions given in knots

TABLE 28

WEATHER INFORMATION FOR Sioux City, Iowa (14943)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.3	19.1	.73		11.1	4.7	22.0	.80		8.1
FEB	6.4	23.2	.74		11.3	4.5	29.0	.805		8.5
MAR	6.9	35.0	.73		12.6	5.2	39.5	.82		9.4
APR	6.5	49.2	.63		12.9	4.2	51.7	.69		9.7
MAY	6.5	60.4	.65		11.7	4.7	65.5	.69		8.9
JUNE	5.7	70.3	.68		10.8	3.5	75.0	.745		7.6
JULY	4.8	76.3	.68		9.0	3.2	79.0	.74		6.4
AUG	4.8	73.6	.71		8.9	3.0	76.0	.77		6.1
SEPT	4.8	64.4	.68		9.9	3.1	65.7	.77		6.7
OCT	4.8	52.6	.66		10.4	2.5	58.0	.735		6.9
NOV	6.4	35.5	.71		11.6	4.0	40.0	.735		8.0
DEC	6.6	23.4	.74		10.7	4.3	31.0	.80		8.2

LATITUDE = 42° 24'N

LONGITUDE = 96° 23' W

ELEVATION = 1084 ft.

*Extreme conditions given in knots

TABLE 29

WEATHER INFORMATION FOR Dodge City, Kansas (13985)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	5.3	31.1	.68		14.3	3.0	34.0	.76		10.0
FEB	5.8	35.0	.67		14.9	3.7	38.5	.78		10.1
MAR	5.7	41.8	.64		16.7	3.5	46.7	.76		11.6
APR	5.8	53.6	.60		16.3	3.7	57.5	.685		11.2
MAY	5.8	63.7	.66		15.4	4.0	67.5	.70		11.3
JUNE	4.8	74.4	.62		15.2	3.0	80.0	.71		9.9
JULY	4.6	80.2	.60		13.4	3.2	82.5	.69		9.15
AUG	4.3	79.2	.58		13.3	3.0	80.0	.66		9.15
SEPT	4.0	70.3	.58		14.7	1.7	72.0	.71		10.03
OCT	4.0	58.3	.60		14.1	1.4	61.5	.66		9.8
NOV	4.7	42.8	.63		14.5	2.3	47.0	.737		9.6
DEC	5.2	34.7	.67		14.0	3.2	36.0	.72		9.5

LATITUDE = 37° 46' N

LONGITUDE = 99° 58' W

ELEVATION = 2582 ft.

*Extreme conditions given in knots

TABLE 30

WEATHER INFORMATION FOR Topeka, Kansas (13996)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.2	28.8	.71		11.0	4.3	31.7	.748		8.09
FEB	6.6	33.1	.71		11.4	5.0	38.1	.741		8.09
MAR	6.6	41.7	.68		13.5	4.7	46.5	.731		9.99
APR	6.4	54.4	.63		13.5	5.0	60.1	.687		9.64
MAY	6.4	64.4	.69		12.3	4.7	68.7	.707		8.29
JUNE	6.0	74.7	.71		11.4	4.0	81.0	.767		7.49
JULY	5.4	79.9	.70		9.7	4.0	83.1	.781		5.69
AUG	4.8	78.4	.68		10.0	3.3	79.4	.751		5.79
SEPT	4.5	69.4	.66		10.3	2.0	71.7	.786		5.59
OCT	4.6	58.2	.67		10.3	2.0	62.1	.740		7.09
NOV	5.4	42.6	.67		11.3	3.3	46.4	.741		6.59
DEC	6.0	33.4	.72		11.0	4.3	37.6	.761		7.69

LATITUDE = 39° 04' N

LONGITUDE = 95° 38' W

ELEVATION = 876 ft.

*Extreme conditions given in knots

TABLE 31

WEATHER INFORMATION FOR Lexington, Kentucky (93820)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	7.4	34.5	.78		12.5	4.7	40.0	.81		7.55
FEB	7.0	35.8	.74		12.5	5.2	40.0	.78		8.4
MAR	7.0	43.2	.71		12.6	5.2	48.0	.75		9.1
APR	6.6	54.4	.68		12.1	5.2	58.5	.70		8.6
MAY	6.2	64.5	.70		9.7	4.3	67.7	.72		6.9
JUNE	5.7	73.6	.72		8.5	4.2	76.0	.735		5.9
JULY	5.6	77.4	.73		7.8	3.5	78.0	.77		5.4
AUG	5.0	76.0	.73		7.0	3.2	76.0	.765		4.9
SEPT	4.7	69.3	.70		8.5	2.3	71.0	.75		5.4
OCT	4.7	58.1	.70		9.0	2.0	60.7	.73		6.15
NOV	6.2	44.7	.72		11.4	4.2	45.8	.753		7.5
DEC	6.8	35.9	.76		11.8	5.2	39.5	.805		8.2

LATITUDE = 38° 02' N

LONGITUDE = 84° 36' W

ELEVATION = 966 ft.

*Extreme conditions given in knots

TABLE 32

WEATHER INFORMATION FOR Louisville, Kentucky (93821)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	7.7	34.9	.75		10.2	5.0	40.0	.767		6.6
FEB	7.0	37.2	.71		10.0	5.2	41.0	.76		7.3
MAR	6.8	45.6	.66		10.7	5.2	48.0	.72		8.0
APR	6.6	56.0	.64		10.4	5.1	61.0	.685		7.6
MAY	6.2	65.3	.67		8.1	4.7	69.5	.715		6.0
JUNE	5.7	74.2	.69		7.4	3.7	78.0	.76		5.0
JULY	5.6	77.9	.70		6.7	3.7	80.5	.747		4.6
AUG	5.0	76.1	.71		6.0	3.0	78.0	.745		4.0
SEPT	4.8	70.2	.68		7.0	2.7	72.5	.755		4.6
OCT	5.0	58.6	.70		7.1	2.0	61.5	.737		4.5
NOV	6.0	45.7	.68		9.5	4.2	47.6	.735		6.4
DEC	6.8	36.9	.73		9.3	5.0	41.7	.76		7.05

LATITUDE = 38° 11' N

LONGITUDE = 85° 44' W

ELEVATION = 474 ft.

*Extreme conditions given in knots

TABLE 33

WEATHER INFORMATION FOR New Orleans, Louisiana (12916)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.6	54.6	.78		9.6	4.4	60.0	.80		7.0
FEB	6.3	57.1	.76		10.3	4.0	62.0	.80		8.05
MAR	6.1	61.4	.73		10.2	4.4	65.0	.76		7.8
APR	5.7	67.9	.75		9.7	3.7	72.0	.78		7.2
MAY	5.1	74.4	.75		8.4	3.2	77.0	.77		5.9
JUNE	5.0	80.1	.77		7.0	3.0	81.0	.805		5.0
JULY	6.1	81.6	.79		6.4	4.2	82.3	.82		4.8
AUG	5.4	81.9	.80		6.2	3.2	81.5	.83		4.6
SEPT	5.2	78.3	.79		7.6	3.2	79.0	.798		4.9
OCT	4.0	70.4	.75		7.7	1.3	72.0	.80		5.3
NOV	5.0	60.0	.75		9.0	3.0	62.0	.79		6.0
DEC	6.1	55.4	.78		9.3	4.0	58.5	.80		6.8

LATITUDE = 29° 59.2' N

LONGITUDE = 90° 15.3' W

ELEVATION = 3 ft.

*Extreme conditions given in knots

TABLE 34

WEATHER INFORMATION FOR Shreveport, Louisiana (13957)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.6	47.5	.72		10.6	4.2	52.0	.80		8.1
FEB	6.1	50.3	.68		10.9	4.0	55.5	.76		7.4
MAR	6.2	56.6	.66		11.3	4.2	62.0	.72		8.4
APR	6.5	65.3	.70		11.1	4.1	69.3	.75		7.8
MAY	6.1	73.1	.72		9.5	3.3	75.0	.745		7.2
JUNE	5.1	80.6	.72		8.3	3.0	82.0	.75		6.2
JULY	5.2	83.7	.71		8.1	2.0	84.0	.775		5.8
AUG	4.9	83.8	.70		7.9	2.0	84.0	.75		5.95
SEPT	4.6	78.8	.71		8.0	2.2	78.0	.77		5.8
OCT	4.2	68.3	.68		8.4	1.3	69.0	.765		5.9
NOV	5.3	55.7	.70		9.6	3.0	58.5	.75		7.2
DEC	6.1	49.6	.72		10.1	4.2	51.7	.78		7.82

LATITUDE = 32° 28' N

LONGITUDE = 93° 49' W

ELEVATION = 254 ft.

*Extreme conditions given in knots

TABLE 35

WEATHER INFORMATION FOR Caribou, Maine (14607)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	7.0	10.5	.72		12.4	5.2	17.0	.78		7.8
FEB	6.8	12.5	.71		12.0	4.5	19.0	.76		7.8
MAR	6.8	22.8	.71		12.9	4.6	30.1	.760		7.24
APR	7.2	36.4	.70		11.7	5.6	40.4	.756		7.74
MAY	7.3	49.9	.66		11.4	5.5	53.1	.711		7.64
JUNE	7.4	59.0	.71		10.4	5.0	61.6	.756		7.09
JULY	7.1	64.5	.74		9.8	5.6	68.1	.800		6.79
AUG	6.9	62.6	.77		9.3	4.9	63.8	.796		6.48
SEPT	6.6	53.8	.78		10.4	5.2	58.1	.806		6.38
OCT	7.1	43.0	.78		10.9	5.2	46.6	.811		7.08
NOV	8.1	30.2	.81		11.1	6.4	35.1	.846		6.58
DEC	7.5	15.5	.78		11.5	5.4	21.8	.802		7.38

LATITUDE = 46° 52' N
LONGITUDE = 68° 01' W
ELEVATION = 624 ft.

*Extreme conditions given in knots

TABLE 36

WEATHER INFORMATION FOR Portland, Maine (14764)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.2	21.8	.72		9.3	4.2	27.0	.78		6.4
FEB	5.9	22.8	.71		9.5	4.2	28.0	.77		6.7
MAR	6.1	31.4	.71		10.0	4.7	34.0	.76		6.9
APR	6.4	42.5	.70		10.0	5.0	45.0	.745		7.0
MAY	6.5	53.0	.72		9.2	5.2	55.5	.78		6.6
JUNE	6.3	62.1	.75		8.1	4.4	64.3	.81		5.4
JULY	6.1	68.1	.76		7.6	4.4	70.5	.80		4.8
AUG	5.8	66.8	.78		7.5	4.2	68.0	.815		5.4
SEPT	5.5	58.7	.79		7.8	4.0	60.7	.81		5.4
OCT	5.5	48.6	.77		8.6	4.0	51.5	.80		5.6
NOV	6.6	38.1	.78		8.8	5.1	41.0	.81		5.8
DEC	6.0	25.8	.74		8.9	4.2	32.0	.79		6.0

LATITUDE = 43° 39' N

LONGITUDE = 70° 19' W

ELEVATION = 47 ft.

*Extreme conditions given in knots

TABLE 37

WEATHER INFORMATION FOR Baltimore, Maryland (93721)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.1	34.8	.66		10.3	3.7	40.0	.72		7.4
FEB	6.1	35.7	.66		11.0	4.5	40.0	.725		7.6
MAR	6.1	43.1	.62		11.6	4.3	44.8	.66		8.4
APR	6.3	54.2	.62		11.4	5.0	56.5	.67		8.0
MAY	6.2	64.4	.66		10.0	5.0	66.0	.717		7.4
JUNE	5.5	72.5	.69		9.1	4.1	74.3	.73		6.75
JULY	5.5	76.8	.70		8.6	3.7	79.0	.745		6.5
AUG	5.6	75.0	.72		8.7	3.7	76.5	.78		6.4
SEPT	5.1	68.1	.73		8.9	3.2	69.8	.77		6.6
OCT	4.8	57.0	.70		9.5	1.7	59.5	.75		6.6
NOV	5.9	45.5	.67		9.8	3.6	47.9	.706		7.49
DEC	6.2	35.8	.68		9.6	4.2	39.0	.72		6.65

LATITUDE = 39° 11' N

LONGITUDE = 76° 40' W

ELEVATION = 148 ft.

*Extreme conditions given in knots

TABLE 38

WEATHER INFORMATION FOR Boston, Massachusetts (14739)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.3	29.9	. 4		14.8	4.4	34.7	.68		10.8
FEB	6.1	30.3	.62		14.7	4.3	34.7	.668		10.6
MAR	6.2	37.7	.64		14.5	5.0	38.7	.67		11.73
APR	6.5	47.9	.63		13.8	5.0	49.3	.68		10.4
MAY	6.5	58.8	.64		12.9	5.0	60.0	.71		10.0
JUNE	6.2	67.8	.70		12.0	4.5	70.0	.73		9.4
JULY	6.1	73.7	.66		11.3	4.3	75.5	.725		8.5
AUG	5.7	71.7	.70		11.2	4.1	73.3	.733		8.7
SEPT	5.4	65.3	.67		11.5	2.4	67.0	.74		8.9
OCT	5.5	55.0	.67		12.5	2.2	57.5	.725		9.43
NOV	6.4	44.9	.69		13.4	5.0	47.0	.71		10.2
DEC	6.1	33.3	.65		14.2	4.2	38.0	.72		10.8

LATITUDE = 42° 22' N

LONGITUDE = 71° 02' W

ELEVATION = 15 ft.

*Extreme conditions given in knots

TABLE 39

WEATHER INFORMATION FOR Detroit, Michigan (14822)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	7.8	26.9	.75		11.5	6.1	30.1	.786		8.79
FEB	7.3	27.2	.74		11.5	6.0	31.0	.76		8.4
MAR	7.0	34.8	.70		11.5	5.7	37.5	.725		9.0
APR	6.8	47.6	.64		11.1	4.7	51.0	.677		8.9
MAY	6.4	59.0	.62		9.9	4.5	63.0	.67		7.5
JUNE	6.0	69.7	.65		9.0	4.2	72.3	.67		6.6
JULY	5.3	74.4	.64		8.2	3.7	75.7	.67		6.2
AUG	5.4	72.8	.68		8.0	3.4	75.5	.71		6.23
SEPT	5.4	65.1	.70		8.9	3.0	67.0	.733		6.6
OCT	5.6	53.8	.70		9.5	3.0	56.5	.733		6.9
NOV	7.5	40.4	.72		11.4	6.0	44.0	.747		8.4
DEC	7.7	29.9	.76		11.3	6.0	34.0	.78		8.9

LATITUDE = 42° 25' N

LONGITUDE = 83° 01' W

ELEVATION = 619 ft.

*Extreme conditions given in knots

TABLE 40

WEATHER INFORMATION FOR Muskegon, Michigan (14840)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	8.7	76.0	.79		12.3	7.2	28.0	.816		7.99
FEB	8.1	25.7	.76		11.9	6.5	28.7	.80		8.2
MAR	7.3	32.9	.74		12.3	6.1	36.0	.76		8.6
APR	6.6	45.2	.68		12.4	4.0	48.7	.725		8.4
MAY	6.1	55.8	.62		10.7	4.2	60.8	.70		7.6
JUNE	5.7	66.7	.66		9.0	4.1	70.3	.715		7.1
JULY	4.8	71.3	.69		8.3	3.2	73.8	.73		6.4
AUG	5.1	70.3	.73		8.4	3.5	74.0	.76		5.9
SEPT	5.5	63.0	.74		8.8	3.5	64.0	.76		6.3
OCT	5.9	52.5	.73		11.1	3.3	56.0	.77		7.0
NOV	8.4	39.6	.76		11.8	6.7	43.0	.77		9.0
DEC	8.8	29.9	.80		12.1	7.3	33.0	.82		8.25

LATITUDE = 43° 10' N

LONGITUDE = 86° 14' W

ELEVATION = 625 ft.

*Extreme conditions given in knots

TABLE 41

WEATHER INFORMATION FOR Sault Ste. Marie, Michigan (14847)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	7.9	15.8	.81		10.3	6.1	18.6	.847		6.89
FEB	7.3	15.7	.80		10.3	5.4	19.0	.83		7.3
MAR	7.0	23.8	.77		10.7	5.1	27.5	.79		7.2
APR	6.7	38.0	.72		11.1	5.0	41.0	.78		8.4
MAY	6.6	49.6	.69		10.6	5.1	52.7	.725		7.8
JUNE	6.3	59.0	.75		9.1	4.7	60.8	.805		6.8
JULY	5.8	64.6	.76		8.5	4.2	66.0	.80		6.1
AUG	6.0	64.0	.79		8.4	4.3	66.0	.82		5.9
SEPT	6.9	55.8	.82		9.2	5.7	58.0	.84		6.55
OCT	7.1	46.3	.80		9.7	4.7	48.0	.823		7.0
NOV	8.6	33.3	.83		10.5	7.2	36.0	.845		7.6
DEC	8.2	20.9	.82		10.3	7.1	26.0	.86		8.0

LATITUDE = 46° 28' N

LONGITUDE = 84° 22' W

ELEVATION = 721 ft.

*Extreme conditions given in knots

TABLE 42

WEATHER INFORMATION FOR Duluth, Minnesota (14913)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.8	8.3	.75		12.6	5.1	14.0	.77		9.0
FEB	6.4	11.0	.74		13.0	4.3	19.5	.765		9.0
MAR	6.5	22.2	.74		13.3	5.0	28.0	.76		8.6
APR	6.8	36.8	.68		14.9	5.0	43.0	.71		10.0
MAY	6.6	49.7	.66		13.6	5.3	52.5	.71		9.2
JUNE	6.6	59.7	.73		11.6	5.2	61.8	.75		8.2
JULY	5.9	66.4	.75		10.6	4.4	68.0	.758		7.45
AUG	6.0	64.8	.78		10.4	4.2	66.5	.80		6.7
SEPT	6.7	55.4	.80		11.9	5.1	55.7	.81		7.9
OCT	6.4	44.0	.76		12.4	4.0	49.0	.80		8.5
NOV	7.5	27.0	.80		13.6	6.1	32.5	.80		8.6
DEC	7.3	13.2	.77		12.3	5.5	21.5	.807		8.4

LATITUDE = 46° 50' N

LONGITUDE = 92° 11' W

ELEVATION = 1426 Ft.

*Extreme conditions given in knots

TABLE 43

WEATHER INFORMATION FOR Minneapolis-St. Paul, Minnesota (14922)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.3	14.6	.76		10.6	4.5	18.0	.78		8.03
FEB	6.0	18.2	.74		10.9	4.0	23.5	.77		8.0
MAR	6.6	30.9	.72		11.6	5.2	34.5	.75		8.7
APR	6.4	46.0	.62		12.7	4.3	49.0	.68		9.3
MAY	6.3	58.5	.62		11.7	4.0	61.7	.68		8.87
JUNE	6.0	68.2	.67		11.1	4.5	71.0	.685		8.1
JULY	5.1	74.1	.67		9.5	3.2	76.0	.71		6.8
AUG	5.1	71.5	.69		9.4	3.2	74.0	.733		6.8
SEPT	5.2	62.2	.69		10.5	3.5	62.5	.77		7.0
OCT	5.2	50.4	.67		10.9	3.2	56.0	.743		8.0
NOV	7.0	33.0	.75		11.6	4.5	37.3	.775		8.0
DEC	6.9	19.4	.78		10.7	5.3	26.0	.82		7.4

LATITUDE = 44° 53' N

LONGITUDE = 93° 13' W

ELEVATION = 830 ft.

*Extreme conditions given in knots

TABLE 44

WEATHER INFORMATION FOR Jackson, Mississippi (13956)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.7	48.0	.73		7.7	4.8	54.5	.775		6.25
FEB	6.9	50.7	.72		8.0	4.2	56.2	.765		6.55
MAR	6.1	56.4	.68		8.2	4.2	61.2	.702		6.55
APR	5.8	64.4	.69		7.7	4.2	68.5	.699		6.22
MAY	5.3	72.5	.71		6.2	2.5	74.7	.735		4.85
JUNE	5.9	79.4	.69		5.4	3.1	83.2	.758		4.24
JULY	5.6	81.6	.74		4.9	3.7	82.9	.788		3.17
AUG	5.1	81.3	.75		4.6	2.2	84.3	.758		3.24
SEPT	5.3	76.2	.75		5.6	2.2	77.6	.776		3.88
OCT	5.2	66.5	.74		5.3	1.7	67.9	.786		4.04
NOV	5.7	54.9	.72		6.8	3.1	55.3	.726		5.34
DEC	6.1	49.0	.74		7.1	4.4	54.6	.746		5.74

LATITUDE = 32° 19' N

LONGITUDE = 90° 05' W

ELEVATION = 330 ft.

*Extreme conditions given in knots

TABLE 45

WEATHER INFORMATION FOR St. Louis, Missouri (13994)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.8	31.9	.69		10.1	4.3	35.0	.78		8.0
FEB	6.4	34.7	.65		10.6	5.0	39.5	.755		8.2
MAR	6.7	42.6	.64		11.8	4.7	47.0	.72		8.9
APR	6.6	54.9	.61		11.4	5.0	60.0	.66		8.55
MAY	6.2	64.2	.64		9.6	4.7	70.0	.68		7.4
JUNE	5.9	74.1	.67		8.4	4.0	80.0	.72		5.8
JULY	5.7	78.1	.68		7.6	4.0	82.0	.74		5.3
AUG	5.3	76.8	.68		7.4	3.3	79.0	.70		4.6
SEPT	4.8	69.5	.70		7.9	2.0	73.0	.75		5.4
OCT	4.7	58.4	.64		8.5	2.0	63.5	.713		5.7
NOV	5.9	44.1	.70		9.9	3.3	47.7	.705		7.6
DEC	6.8	34.8	.73		10.3	4.3	40.0	.775		7.2

LATITUDE = 38° 45' N

LONGITUDE = 90° 23' W

ELEVATION = 560 ft.

*Extreme conditions given in knots

TABLE 46

WEATHER INFORMATION FOR Springfield, Missouri (13995)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.9	32.7	.76		13.3	3.7	36.3	.79		9.0
FEB	6.3	36.8	.72		13.7	4.2	40.0	.757		9.0
MAR	6.6	44.9	.70		14.7	4.2	48.5	.725		10.2
APR	6.3	55.5	.66		14.1	4.3	61.0	.70		9.1
MAY	6.3	63.6	.72		12.2	4.2	67.8	.75		8.0
JUNE	5.8	72.9	.73		11.7	4.0	79.0	.80		7.0
JULY	5.6	77.5	.73		10.1	3.5	79.0	.80		6.3
AUG	5.0	76.5	.71		9.9	3.2	78.0	.76		5.7
SEPT	4.2	69.1	.68		10.9	1.7	72.0	.805		6.6
OCT	4.7	58.4	.69		11.6	1.7	62.5	.76		7.4
NOV	5.2	44.5	.70		13.2	3.0	48.0	.745		7.5
DEC	6.2	35.7	.73		13.3	4.0	40.0	.77		8.6

LATITUDE = 37° 14' N

LONGITUDE = 93° 23' W

ELEVATION = 1265 ft.

*Extreme conditions given in knots

TABLE 47

WEATHER INFORMATION FOR Billings, Montana (24033)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.9	22.9	.63		12.6	5.2	33.0	.697		9.5
FEB	6.9	26.1	.66		12.1	5.5	36.0	.69		9.4
MAR	7.2	34.1	.65		11.8	5.3	39.7	.697		8.4
APR	7.0	46.2	.57		11.8	5.0	51.0	.65		9.0
MAY	6.4	56.0	.56		11.1	4.7	58.0	.645		8.8
JUNE	6.0	64.0	.60		10.6	3.7	68.0	.655		7.9
JULY	4.0	73.3	.47		9.9	2.2	75.5	.54		7.85
AUG	4.1	71.0	.46		9.6	2.5	73.5	.535		7.4
SEPT	5.2	60.0	.52		10.4	3.5	63.5	.59		8.2
OCT	5.5	49.2	.56		10.9	3.2	53.5	.645		8.0
NOV	6.7	35.8	.62		12.3	4.3	43.0	.663		9.2
DEC	6.7	27.2	.62		12.9	5.0	33.0	.685		9.3

LATITUDE = 45° 48' N

LONGITUDE = 108° 32' W

ELEVATION = 3567 ft.

*Extreme conditions given in knots

TABLE 48

WEATHER INFORMATION FOR Helena, Montana (24144)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	7.3	18.6	.69		6.7	6.0	29.0	.72		4.5
FEB	7.3	23.2	.68		7.7	6.0	33.5	.715		5.4
MAR	7.2	31.4	.64		8.5	5.4	37.0	.70		5.75
APR	7.2	43.3	.57		9.4	5.2	46.5	.61		6.8
MAY	6.9	52.9	.58		9.0	5.3	56.0	.60		7.0
JUNE	6.4	59.5	.58		8.8	4.2	61.7	.62		6.4
JULY	4.0	68.4	.50		8.0	2.1	71.0	.56		5.75
AUG	4.4	66.2	.48		7.7	2.0	70.0	.54		5.2
SEPT	5.4	56.0	.55		7.6	3.5	60.0	.64		5.05
OCT	5.9	45.6	.60		7.3	3.2	48.0	.68		5.2
NOV	7.2	31.6	.68		7.3	5.0	37.5	.70		4.9
DEC	7.3	24.2	.70		7.0	6.0	30.0	.745		4.8

LATITUDE = 46° 36' N

LONGITUDE = 112° 00' W

ELEVATION = 3828 ft.

*Extreme conditions given in knots

TABLE 49

WEATHER INFORMATION FOR North Platte, Nebraska (24023)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.0	24.0	.72		9.7	4.3	26.5	.76		6.7
FEB	6.6	27.9	.70		10.6	4.7	31.0	.78		7.4
MAR	6.5	35.0	.68		12.3	4.0	39.3	.745		9.0
APR	6.4	47.7	.61		13.3	4.2	50.7	.68		9.8
MAY	6.5	58.5	.66		12.5	5.0	61.5	.70		9.2
JUNE	4.9	69.1	.65		11.4	3.0	73.0	.74		8.3
JULY	4.4	76.1	.63		10.2	3.2	78.0	.725		7.3
AUG	4.6	74.5	.64		10.1	3.0	74.5	.733		6.7
SEPT	4.4	63.7	.61		10.3	2.7	64.8	.74		7.8
OCT	4.2	51.0	.62		10.1	2.2	55.0	.71		7.2
NOV	5.5	35.5	.67		10.6	4.0	39.0	.72		6.6
DEC	5.7	27.4	.70		9.9	4.0	30.0	.755		6.9

LATITUDE = 41° 08' N

LONGITUDE = 100° 41' W

ELEVATION = 2775 ft.

*Extreme conditions given in knots

TABLE 50

WEATHER INFORMATION FOR Omaha, Nebraska (14942)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.1	22.3	.72		11.4	4.7	25.5	.78		8.3
FEB	6.4	26.5	.74		11.8	4.3	32.0	.765		8.8
MAR	6.7	36.9	.68		13.1	5.0	43.5	.773		10.3
APR	6.3	51.7	.58		13.7	4.0	55.0	.68		9.65
MAY	6.3	63.0	.62		11.8	4.7	67.5	.685		9.15
JUNE	5.6	73.1	.65		11.0	3.7	77.0	.73		7.5
JULY	4.7	78.5	.66		9.4	3.2	81.0	.725		6.8
AUG	4.6	76.2	.68		9.6	3.0	77.0	.74		6.5
SEPT	4.6	66.9	.68		10.2	3.0	68.0	.75		6.75
OCT	4.5	55.7	.63		10.4	2.1	60.0	.72		7.4
NOV	5.7	38.9	.68		11.7	3.5	44.0	.76		7.8
DEC	6.2	28.2	.70		11.2	3.7	34.0	.78		8.0

LATITUDE = 41° 18' N

LONGITUDE = 95° 54' W

ELEVATION = 978 ft.

*Extreme conditions given in knots

TABLE 51

WEATHER INFORMATION FOR Elko, Nevada (24121)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.8	22.6	.72		5.4	4.3	31.0	.79		3.0
FEB	6.5	28.0	.70		5.9	4.5	38.0	.76		3.6
MAR	6.8	35.6	.62		6.9	4.4	38.0	.71		4.6
APR	6.4	44.3	.51		7.2	4.5	48.0	.62		5.53
MAY	6.2	52.0	.51		7.0	4.4	58.0	.615		4.8
JUNE	4.2	60.0	.42		6.8	2.4	68.0	.55		4.7
JULY	3.0	69.6	.33		6.3	1.3	74.8	.40		4.55
AUG	2.9	66.9	.32		6.1	1.4	72.0	.46		4.35
SEPT	3.0	57.9	.37		5.5	1.0	62.0	.44		4.0
OCT	4.2	46.9	.48		5.3	2.1	49.7	.60		3.6
NOV	5.6	34.2	.63		4.9	2.4	38.6	.711		2.59
DEC	6.5	26.4	.73		4.9	3.4	31.1	.814		2.49

LATITUDE = 40° 50' N

LONGITUDE = 115° 47' W

ELEVATION = 5050 ft.

*Extreme conditions given in knots

TABLE 52

WEATHER INFORMATION FOR Las Vegas, Nevada (23169)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	5.2	44.2	.47		6.5	2.0	47.0	.555		4.45
FEB	4.3	50.4	.37		7.9	2.0	54.5	.48		5.0
MAR	4.2	56.5	.28		9.7	2.0	58.0	.395		7.0
APR	3.8	65.6	.23		10.3	2.0	69.5	.33		6.15
MAY	3.3	74.1	.19		11.0	2.0	78.0	.26		7.3
JUNE	1.6	83.6	.15		11.1	0.4	87.5	.19		7.6
JULY	2.8	90.5	.22		9.9	1.0	91.8	.26		6.5
AUG	2.3	88.4	.22		9.6	1.0	90.3	.30		6.3
SEPT	1.6	80.7	.20		8.6	0.1	81.8	.30		5.1
OCT	2.4	67.4	.26		7.6	1.0	70.5	.36		5.35
NOV	3.2	53.9	.35		6.3	2.0	56.0	.473		4.4
DEC	4.4	46.8	.40		6.3	2.0	47.5	.555		3.7

LATITUDE = 36° 05' N

LONGITUDE = 115° 10' W

ELEVATION = 2162 ft.

*Extreme conditions given in knots

TABLE 53

WEATHER INFORMATION FOR Reno, Nevada (23185)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	5.9	31.9	.69		6.0	3.5	35.5	.66		3.3
FEB	6.1	36.1	.66		6.3	3.2	41.0	.60		3.7
MAR	5.8	41.0	.55		7.7	3.3	43.0	.545		5.5
APR	5.4	47.5	.49		7.9	3.2	51.3	.44		5.2
MAY	5.0	53.4	.48		7.7	3.0	59.5	.29		5.2
JUNE	3.3	60.1	.45		7.2	1.5	67.0	.28		4.7
JULY	2.1	68.2	.40		6.5	0.3	73.0	.43		4.53
AUG	1.9	66.5	.40		6.2	0.5	71.0	.485		4.4
SEPT	2.4	60.3	.46		5.5	0.3	62.7	.46		3.7
OCT	4.1	50.2	.53		5.5	2.0	52.0	.49		3.4
NOV	5.3	39.3	.62		5.1	1.7	41.5	.58		2.4
DEC	6.2	33.4	.71		4.8	3.5	35.5	.64		2.9

LATITUDE = 39° 30' N

LONGITUDE = 119° 47' W

ELEVATION = 4404 ft.

*Extreme conditions given in knots

TABLE 54

WEATHER INFORMATION FOR Concord, New Hampshire (14745)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.2	21.2	.71		7.3	4.2	27.0	.743		5.05
FEB	6.0	22.7	.69		7.9	4.0	28.0	.72		4.8
MAR	6.1	31.7	.67		8.2	5.0	35.0	.705		5.85
APR	6.5	43.8	.65		7.8	5.0	46.5	.69		5.45
MAY	6.5	55.5	.66		7.0	5.2	59.3	.70		5.05
JUNE	6.1	64.5	.69		6.4	4.3	67.5	.75		4.2
JULY	6.0	69.6	.71		5.5	4.5	73.0	.76		3.6
AUG	5.8	67.4	.75		5.2	4.1	69.7	.76		3.4
SEPT	5.7	59.3	.76		5.4	3.7	61.0	.785		3.7
OCT	5.6	48.7	.74		5.9	4.0	52.0	.763		4.0
NOV	6.7	37.6	.74		6.6	5.0	41.0	.765		4.4
DEC	6.1	25.0	.72		6.9	4.3	30.0	.77		4.7

LATITUDE = 43° 12' N

LONGITUDE = 71° 31' W

ELEVATION = 342 ft.

*Extreme conditions given in knots

TABLE 55

WEATHER INFORMATION FOR Newark, New Jersey (14734)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.5	33.3	.66		11.2	4.2	37.0	.69		8.4
FEB	6.4	33.7	.64		11.5	4.5	37.5	.68		8.2
MAR	6.1	41.5	.62		12.1	5.1	41.8	.66		9.1
APR	6.5	52.3	.62		11.2	4.5	53.0	.65		8.9
MAY	6.4	62.5	.64		10.0	4.5	65.0	.68		7.7
JUNE	6.0	72.3	.66		9.3	4.5	73.0	.68		7.2
JULY	6.1	77.3	.66		8.8	4.2	78.7	.70		6.7
AUG	6.0	75.4	.69		8.5	4.0	76.5	.72		6.4
SEPT	5.5	68.3	.70		8.8	3.4	70.0	.72		7.05
OCT	5.2	57.6	.69		9.3	3.2	59.8	.72		7.2
NOV	6.0	45.9	.67		10.1	4.2	48.5	.69		7.0
DEC	6.2	35.3	.67		10.6	4.3	38.7	.72		7.8

LATITUDE = 40° 42' N

LONGITUDE = 74° 10' W

ELEVATION = 11 ft.

*Extreme conditions given in knots

TABLE 56

WEATHER INFORMATION FOR Albuquerque, New Mexico (23050)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	5.0	33.7	.56		8.1	1.5	40.0	.585		5.4
FEB	4.9	39.5	.49		8.9	3.0	44.0	.54		6.0
MAR	4.9	46.0	.40		10.1	3.0	49.0	.43		7.33
APR	4.8	55.5	.35		11.0	3.1	58.0	.40		7.6
MAY	4.3	65.3	.32		10.4	2.0	68.0	.355		7.35
JUNE	3.3	74.9	.30		9.8	1.0	77.5	.36		6.93
JULY	4.4	79.0	.42		9.1	3.2	7[illegible].5	.46		6.3
AUG	4.3	76.9	.47		8.0	2.2	77.3	.52		5.6
SEPT	3.1	69.9	.40		8.5	0.7	72.0	.53		6.0
OCT	3.5	58.2	.44		8.2	1.1	60.8	.52		5.5
NOV	3.6	44.0	.46		7.8	1.7	47.7	.56		4.7
DEC	4.5	36.0	.55		7.4	2.0	40.0	.61		5.0

LATITUDE = 35° 03' N

LONGITUDE = 106° 37' W

ELEVATION = 5310 ft.

*Extreme conditions given in knots

TABLE 57

WEATHER INFORMATION FOR Albany, New York (14735)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	7.0	22.7	.73		9.7	4.7	29.0	.755		7.4
FEB	6.8	23.7	.71		10.4	5.4	29.0	.74		7.35
MAR	6.8	33.0	.69		10.5	5.5	36.0	.71		7.5
APR	7.0	46.2	.64		10.5	5.0	49.5	.67		8.15
MAY	6.8	57.9	.65		9.0	5.4	61.0	.67		6.6
JUNE	6.4	67.3	.67		8.1	4.5	70.0	.70		5.8
JULY	6.2	72.1	.68		7.3	4.5	74.5	.73		5.6
AUG	6.0	70.0	.73		6.9	4.5	72.0	.75		5.3
SEPT	5.8	61.6	.76		7.3	3.3	63.0	.77		5.6
OCT	5.9	50.8	.74		7.9	4.0	54.3	.76		5.9
NOV	7.3	39.1	.74		8.8	5.7	42.0	.74		6.1
DEC	7.1	26.5	.75		8.9	5.5	32.0	.78		6.3

LATITUDE = 42° 45' N

LONGITUDE = 73° 48' W

ELEVATION = 275 ft.

*Extreme conditions given in knots

TABLE 58

WEATHER INFORMATION FOR Buffalo, New York (14733)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	8.3	25.5	.77		15.1	7.0	30.5	.80		9.8
FEB	8.1	24.7	.76		15.0	6.5	31.0	.79		9.9
MAR	7.4	33.0	.74		14.9	6.1	35.0	.77		9.2
APR	7.1	43.8	.70		13.8	5.2	48.0	.74		8.8
MAY	6.7	55.4	.70		12.5	5.0	59.3	.735		8.85
JUNE	6.0	65.5	.70		12.0	4.5	70.0	.72		8.2
JULY	5.6	70.6	.69		11.2	4.1	73.5	.71		7.4
AUG	5.6	68.9	.71		10.7	4.2	72.0	.747		7.0
SEPT	5.9	62.4	.73		11.5	3.9	65.1	.76		7.1
OCT	6.0	51.2	.73		12.2	3.3	56.0	.756		8.09
NOV	8.1	39.9	.74		14.1	6.3	43.0	.781		8.19
DEC	8.2	29.0	.76		14.6	7.0	33.7	.80		9.09

LATITUDE = 42° 56' N

LONGITUDE = 75° 44' W

ELEVATION = 693 ft.

*Extreme conditions given in knots

TABLE 59

WEATHER INFORMATION FOR New York, New York (14732)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.5	33.6	.61		14.3	4.5	38.0	.68		10.4
FEB	6.3	33.6	.58		14.4	4.5	38.5	.667		10.6
MAR	6.3	40.8	.63		14.6	5.1	41.9	.657		10.35
APR	6.4	51.2	.59		13.1	4.5	52.8	.645		9.4
MAY	6.4	62.1	.60		11.8	4.7	64.5	.68		9.0
JUNE	5.9	71.5	.62		10.9	4.2	73.0	.68		8.7
JULY	6.0	76.8	.62		10.4	4.2	79.0	.70		7.99
AUG	6.0	75.4	.64		10.3	3.9	77.0	.701		7.69
SEPT	5.9	68.8	.64		11.1	3.4	71.1	.701		8.09
OCT	5.2	58.6	.61		11.9	3.2	61.0	.681		8.6
NOV	6.3	47.4	.62		12.9	4.3	49.7	.661		8.99
DEC	6.3	36.4	.64		13.7	4.5	41.0	.701		9.89

LATITUDE = 40° 46' N

LONGITUDE = 73° 54' W

ELEVATION = 11 ft.

*Extreme conditions given in knots

TABLE 60

WEATHER INFORMATION FOR Charlotte, North Carolina (13881)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.4	42.3	.70		8.6	4.2	48.0	.717		5.5
FEB	6.1	44.4	.66		8.8	4.2	48.0	.70		5.8
MAR	6.2	51.0	.65		9.4	4.0	53.5	.67		6.3
APR	5.5	59.7	.63		9.4	4.1	63.0	.66		6.2
MAY	6.0	68.3	.66		7.7	4.2	73.3	.70		5.4
JUNE	5.9	76.6	.68		7.0	4.3	76.8	.75		5.0
JULY	6.2	78.6	.74		6.8	4.3	78.9	.787		4.75
AUG	5.7	77.3	.74		6.9	3.5	78.6	.78		4.6
SEPT	5.8	72.6	.74		7.5	3.7	74.0	.75		4.8
OCT	4.8	61.5	.72		7.7	1.0	63.5	.76		4.6
NOV	5.1	50.4	.70		7.6	3.0	54.0	.71		4.8
DEC	5.8	43.0	.70		7.6	4.0	45.0	.73		4.7

LATITUDE = 35° 13' N

LONGITUDE = 80° 56' W

ELEVATION = 725 ft.

*Extreme conditions given in knots

TABLE 61

WEATHER INFORMATION FOR Wilmington, North Carolina (13748)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	5.9	47.9	.75		10.4	4.1	53.0	.79		6.0
FEB	5.9	48.7	.74		11.5	4.0	54.0	.76		6.7
MAR	5.7	54.2	.71		11.7	4.1	57.5	.718		6.8
APR	5.0	62.5	.71		12.2	3.4	67.0	.707		6.8
MAY	5.5	70.5	.75		10.5	3.5	74.0	.76		6.2
JUNE	5.8	77.7	.78		9.7	4.0	80.0	.80		5.8
JULY	5.9	80.0	.80		9.3	4.4	82.0	.82		5.2
AUG	5.8	79.4	.82		9.1	4.0	80.5	.833		4.4
SEPT	5.8	75.2	.82		9.6	4.0	76.0	.82		5.5
OCT	4.6	65.4	.79		9.4	2.0	67.3	.83		5.7
NOV	4.9	55.4	.78		9.5	2.3	58.0	.77		5.8
DEC	5.3	48.2	.73		9.5	3.7	51.7	.773		5.7

LATITUDE = 34° 16' N

LONGITUDE = 77° 55' W

ELEVATION = 28 ft.

*Extreme conditions given in knots

TABLE 62

WEATHER INFORMATION FOR Bismarck, North Dakota (24011)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.6	9.2	.75		10.1	5.0	17.5	.78		7.2
FEB	6.7	12.7	.76		10.3	5.2	21.5	.80		7.4
MAR	7.0	26.7	.76		11.6	5.2	34.0	.80		7.8
APR	6.6	43.1	.65		12.9	4.5	47.6	.70		9.55
MAY	6.4	54.8	.61		12.7	5.1	58.0	.68		9.5
JUNE	6.1	64.3	.67		11.9	4.7	69.0	.75		8.2
JULY	4.7	72.1	.65		10.0	3.2	74.0	.69		7.8
AUG	4.8	69.3	.63		10.2	3.0	71.8	.68		7.1
SEPT	5.4	58.5	.64		10.9	3.5	60.0	.71		7.6
OCT	5.6	45.7	.66		10.5	3.2	50.0	.72		7.7
NOV	6.9	28.4	.76		11.2	4.3	35.0	.755		7.1
DEC	6.8	15.5	.76		9.8	5.1	24.0	.80		6.5

LATITUDE = 46° 46' N

LONGITUDE = 100° 45' W

ELEVATION = 1650 ft.

*Extreme conditions given in knots

TABLE 63

WEATHER INFORMATION FOR Cleveland, Ohio (14820)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	8.1	28.4	.74		12.4	6.5	33.1	.81		9.09
FEB	7.9	28.5	.74		12.5	6.4	33.0	.80		8.1
MAR	7.4	35.1	.80		12.7	6.1	38.5	.76		9.2
APR	7.0	47.0	.68		12.1	5.3	52.0	.72		9.0
MAY	6.6	58.0	.64		10.6	4.7	63.5	.70		7.8
JUNE	5.8	67.8	.69		9.5	4.5	72.0	.71		6.8
JULY	5.5	71.9	.70		8.8	4.1	76.0	.72		6.93
AUG	5.5	70.4	.74		8.5	3.7	74.0	.76		6.4
SEPT	5.5	64.2	.72		9.2	3.0	67.0	.76		6.9
OCT	5.7	53.4	.69		10.2	3.0	58.0	.745		7.5
NOV	7.8	41.3	.71		12.4	6.2	43.8	.77		9.0
DEC	8.1	30.5	.74		12.5	7.0	36.0	.81		8.9

LATITUDE = 41° 24' N

LONGITUDE = 81° 51' W

ELEVATION = 777 ft.

*Extreme conditions given in knots

TABLE 64

WEATHER INFORMATION FOR Columbus, Ohio (14821)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	8.1	29.7	.78		10.0	5.6	35.1	.781		7.59
FEB	7.5	31.2	.74		10.1	6.1	36.0	.767		7.6
MAR	7.3	39.8	.70		10.7	5.7	43.0	.72		8.4
APR	7.1	50.2	.68		10.0	5.5	56.0	.696		8.0
MAY	6.5	60.8	.69		8.1	5.1	66.5	.72		6.45
JUNE	6.1	70.7	.70		6.8	4.7	73.5	.72		5.2
JULY	5.8	74.4	.70		6.1	4.1	76.0	.74		4.5
AUG	5.4	72.4	.72		5.7	3.7	75.0	.755		4.2
SEPT	5.2	66.5	.71		6.5	2.5	68.5	.755		4.6
OCT	5.2	54.5	.72		7.2	2.0	58.3	.76		5.07
NOV	7.0	41.9	.73		9.6	5.3	44.0	.76		7.0
DEC	7.6	31.7	.77		9.2	6.1	36.5	.78		6.8

LATITUDE = 40° 00' N

LONGITUDE = 82° 53' W

ELEVATION = 815 ft.

*Extreme conditions given in knots

TABLE 65

WEATHER INFORMATION FOR Oklahoma City, Oklahoma (13967)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	5.9	37.0	.76		14.0	2.0	41.0	.80		9.6
FEB	5.7	41.3	.65		14.1	3.3	44.7	.78		10.0
MAR	5.7	48.5	.59		15.7	3.4	53.5	.74		11.55
APR	5.9	59.9	.63		15.5	4.1	64.7	.68		11.4
MAY	5.8	68.4	.65		13.8	4.1	71.0	.76		9.6
JUNE	4.9	78.0	.68		13.2	2.7	80.0	.755		8.0
JULY	4.8	82.5	.64		11.6	2.7	84.5	.76		8.0
AUG	4.2	82.8	.62		11.3	2.3	83.7	.72		7.8
SEPT	4.3	73.8	.70		11.8	1.0	76.0	.76		7.9
OCT	4.1	62.9	.60		12.6	1.3	66.0	.73		9.4
NOV	5.4	48.4	.66		12.8	2.3	53.5	.74		8.9
DEC	5.1	40.3	.55		13.2	3.3	43.0	.725		9.8

LATITUDE = 35° 24' N

LONGITUDE = 97° 36' W

ELEVATION = 1285 ft.

*Extreme conditions given in knots

TABLE 66

WEATHER INFORMATION FOR Astoria, Oregon

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND
JAN	8.5	40.7	.82		9.0					
FEB	8.2	42.8	.82		8.8					
MAR	8.1	44.5	.80		8.7					
APR	8.0	49.0	.79		8.4					
MAY	7.7	53.3	.79		8.3					
JUNE	7.7	57.3	.81		8.2					
JULY	6.6	60.6	.80		8.4					
AUG	6.6	61.0	.82		7.7					
SEPT	6.3	58.0	.82		7.1					
OCT	7.5	52.9	.84		7.5					
NOV	8.1	46.3	.85		8.4					
DEC	8.7	43.1	.86		8.9					

LATITUDE = 47° 09' N

LONGITUDE = 123° 53' W

ELEVATION = 8 ft.

TABLE 67

WEATHER INFORMATION FOR Pendleton, Oregon (24155)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	8.2	32.2	.79		8.3	6.5	40.0	.82		5.1
FEB	7.9	37.4	.74		9.0	6.4	44.0	.777		6.2
MAR	7.2	45.1	.62		10.1	5.0	45.0	.70		6.8
APR	6.6	52.0	.56		10.5	4.5	53.5	.66		8.0
MAY	6.0	59.6	.53		10.3	4.5	61.0	.59		7.6
JUNE	5.2	65.8	.48		10.5	3.0	69.5	.54		7.6
JULY	2.6	73.6	.37		9.7	0.4	77.5	.40		7.3
AUG	3.4	71.9	.40		9.2	1.5	76.5	.45		6.8
SEPT	4.0	64.2	.47		9.0	2.2	66.0	.50		6.4
OCT	5.8	53.7	.62		8.2	3.5	56.0	.72		5.6
NOV	7.7	41.3	.76		8.0	5.0	45.0	.80		5.4
DEC	8.4	36.5	.80		8.4	7.0	40.0	.86		5.6

LATITUDE = 45° 41' N

LONGITUDE = 118° 51' W

ELEVATION = 1482 ft.

*Extreme conditions given in knots

TABLE 68

WEATHER INFORMATION FOR Portland, Oregon (24229)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	8.6	38.4	.82		10.0	6.5	43.7	.86		6.6
FEB	8.3	42.0	.79		8.8	6.3	48.0	.82		5.6
MAR	8.3	46.1	.74		8.5	5.7	46.8	.80		5.8
APR	7.6	51.8	.72		7.2	5.5	52.5	.74		4.3
MAY	7.3	57.4	.70		6.8	6.1	58.7	.727		4.6
JUNE	6.8	62.0	.68		6.8	3.7	64.3	.74		4.7
JULY	4.5	67.2	.66		7.5	2.5	68.5	.70		5.6
AUG	5.3	66.6	.68		7.0	2.7	69.5	.74		4.8
SEPT	5.6	62.2	.71		6.2	3.5	64.0	.78		4.1
OCT	7.4	54.2	.81		6.5	5.4	56.0	.835		4.0
NOV	8.2	45.1	.83		8.3	6.0	49.3	.85		5.6
DEC	9.0	41.3	.84		9.6	7.0	43.7	.868		6.6

LATITUDE = 45° 36' N

LONGITUDE = 122° 36' W

ELEVATION = 21 ft.

*Extreme conditions given in knots

TABLE 69

WEATHER INFORMATION FOR Avoca, Pennsylvania

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND
JAN	7.2	27.7	.70		8.8					
FEB	7.2	28.3	.69		9.3					
MAR	7.1	36.2	.67		9.1					
APR	6.9	48.4	.62		9.5					
MAY	6.7	59.6	.63		8.9					
JUNE	6.0	68.2	.68		7.8					
JULY	6.1	72.4	.69		7.4					
AUG	6.2	70.0	.73		7.2					
SEPT	5.9	62.5	.75		7.5					
OCT	5.8	51.0	.71		7.9					
NOV	7.4	39.6	.70		8.7					
DEC	7.5	29.4	.72		8.8					

LATITUDE = 41° 20' N

LONGITUDE = 75° 44' W

ELEVATION = 930 ft.

TABLE 70

WEATHER INFORMATION FOR Philadelphia, Pennsylvania (13739)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.8	33.2	.70		10.4	4.5	38.0	.72		7.6
FEB	6.3	33.6	.67		11.1	4.7	39.0	.70		8.0
MAR	6.2	42.3	.65		11.7	5.1	43.7	.665		8.6
APR	6.5	51.6	.66		11.2	5.1	55.3	.65		8.5
MAY	6.6	63.1	.66		9.8	5.2	65.3	.72		7.2
JUNE	6.2	72.1	.68		9.0	4.5	73.3	.69		6.7
JULY	6.1	76.3	.70		8.2	4.3	79.0	.727		6.37
AUG	5.9	74.0	.72		7.8	3.7	76.0	.743		5.71
SEPT	5.6	67.7	.72		8.1	3.7	69.0	75.7		6.1
OCT	5.6	56.6	.72		9.0	3.0	59.6	.73		6.9
NOV	6.2	45.9	.70		9.7	4.3	47.3	.71		6.54
DEC	6.4	35.9	.59		10.1	4.7	39.5	.716		7.7

LATITUDE = 69° 53' N

LONGITUDE = 75° 15' W

ELEVATION = 7 ft.

*Extreme conditions given in knots

TABLE 71

WEATHER INFORMATION FOR Scranton, Pennsylvania (14777)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	7.7	26.9	.72		9.2	5.3	32.7	.746		6.35
FEB	7.4	27.1	.72		10.2	6.0	32.5	.723		6.5
MAR	7.1	36.3	.69		9.5	5.7	38.5	.706		7.0
APR	6.9	47.0	.64		9.9	5.3	51.5	.655		6.8
MAY	6.7	58.9	.64		9.3	5.1	62.5	.696		6.0
JUNE	6.1	67.8	.68		8.4	4.2	70.0	.695		6.0
JULY	6.5	72.2	.71		7.6	4.2	74.7	.735		5.4
AUG	6.1	70.0	.73		7.1	4.5	72.0	.755		4.7
SEPT	6.2	63.2	.75		7.7	3.3	64.0	.785		5.2
OCT	5.9	52.2	.72		8.5	3.0	55.0	.742		5.55
NOV	7.1	40.7	.69		9.3	5.7	43.0	.745		5.9
DEC	7.2	29.6	.71		9.2	6.0	34.3	.784		5.6

LATITUDE = 41° 20' N

LONGITUDE = 75° 44' W

ELEVATION = 940 ft.

*Extreme conditions given in knots

TABLE 72

WEATHER INFORMATION FOR Charleston, South Carolina (13880)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.2	49.8	.74		9.3	4.4	56.0	.76		6.6
FEB	6.1	51.5	.71		10.4	4.2	56.0	.765		7.5
MAR	6.0	56.7	.71		10.4	4.0	59.7	.73		7.8
APR	5.4	64.8	.72		10.2	3.5	65.7	.75		7.63
MAY	5.9	72.9	.75		8.9	3.7	74.0	.80		5.6
JUNE	6.3	79.2	.78		8.6	4.5	78.7	.81		6.0
JULY	6.6	80.6	.81		8.1	5.2	79.7	.84		5.5
AUG	6.1	79.7	.82		7.5	4.1	79.0	.838		5.0
SEPT	6.3	75.6	.82		8.2	4.4	74.9	.86		5.6
OCT	5.0	66.2	.77		8.1	2.0	67.5	.83		5.65
NOV	5.1	55.9	.76		8.3	2.7	58.5	.78		6.05
DEC	5.9	50.0	.74		8.7	4.2	53.0	.767		6.1

LATITUDE = 32° 54' N

LONGITUDE = 80° 02' W

ELEVATION = 40 ft.

*Extreme conditions given in knots

TABLE 73

WEATHER INFORMATION FOR Columbia, South Carolina (13883)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.0	46.9	.72		7.1	4.2	52.0	.718		5.2
FEB	5.9	48.4	.70		7.7	4.0	52.0	.70		5.65
MAR	5.8	54.4	.66		8.4	4.0	57.5	.67		6.4
APR	5.2	63.6	.64		8.7	3.7	65.5	.66		6.0
MAY	5.4	72.2	.66		7.0	3.2	75.5	.70		4.9
JUNE	5.7	79.7	.69		6.9	3.5	79.5	.75		4.9
JULY	6.0	81.6	.72		6.8	4.4	81.5	.787		4.9
AUG	5.4	80.5	.74		6.1	3.5	81.0	.78		4.3
SEPT	5.5	75.3	.76		6.4	3.7	74.8	.75		4.35
OCT	4.4	64.7	.74		6.1	2.0	66.0	.76		4.0
NOV	4.8	53.7	.72		6.4	2.3	56.5	.71		4.2
DEC	5.7	46.4	.72		6.5	4.0	49.0	.73		4.6

LATITUDE = 33° 57' N

LONGITUDE = 81° 07' W

ELEVATION = 217 ft.

*Extreme conditions given in knots

TABLE 74

WEATHER INFORMATION FOR Greer, South Carolina

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND
JAN	5.7	43.7	.66		7.6					
FEB	5.6	45.1	.60		8.5					
MAR	5.1	51.4	.59		8.4					
APR	6.0	60.9	.63		8.3					
MAY	6.0	69.4	.68		7.5					
JUNE	5.9	77.0	.72		6.6					
JULY	6.7	79.0	.76		6.3					
AUG	5.8	78.2	.73		6.0					
SEPT	5.3	72.7	.73		6.3					
OCT	4.1	62.4	.69		7.0					
NOV	5.2	51.3	.65		7.2					
DEC	5.8	43.6	.68		7.3					

LATITUDE = 34° 54' N

LONGITUDE = 82° 13' W

ELEVATION = 957 ft.

TABLE 75

WEATHER INFORMATION FOR Huron, South Dakota (14936)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.6	13.5	.76		11.6	5.1	20.0	.82		8.8
FEB	6.4	17.6	.78		11.9	5.0	24.0	.835		8.6
MAR	7.2	31.7	.77		13.0	5.5	36.0	.84		10.03
APR	6.6	46.4	.66		14.3	4.3	48.7	.71		10.8
MAY	6.2	58.0	.65		13.1	4.3	61.0	.72		10.0
JUNE	5.7	68.2	.70		11.9	4.0	72.0	.765		8.93
JULY	4.6	75.4	.66		11.1	2.7	77.3	.72		8.0
AUG	4.9	72.9	.66		11.0	3.0	75.0	.74		8.2
SEPT	5.0	62.8	.65		12.0	3.3	63.0	.75		8.6
OCT	5.1	50.0	.66		11.7	3.0	54.0	.737		9.0
NOV	6.6	32.5	.75		12.7	3.5	36.0	.775		9.7
DEC	6.7	19.6	.78		11.4	5.0	27.5	.84		8.5

LATITUDE = 44° 23' N
LONGITUDE = 98° 13' W
ELEVATION = 1282 ft.

*Extreme conditions given in knots

TABLE 76

WEATHER INFORMATION FOR Rapid City, South Dakota (24090)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.4	22.0	.66		10.4	4.6	30.0	.731		7.49
FEB	6.5	24.1	.68		10.8	5.1	31.1	.74		7.38
MAR	6.7	31.1	.64		12.6	5.2	38.6	.746		9.49
APR	6.7	44.5	.57		13.1	4.4	48.6	.657		9.99
MAY	6.5	55.7	.59		12.4	4.6	58.1	.651		9.49
JUNE	5.7	64.9	.62		10.8	3.6	71.1	.691		8.09
JULY	4.3	73.8	.55		9.9	2.6	76.1	.621		7.89
AUG	4.3	72.0	.51		10.3	2.0	74.7	.60		7.89
SEPT	4.6	61.6	.51		11.0	3.0	65.1	.624		8.49
OCT	4.7	50.0	.50		10.9	2.9	55.1	.651		8.53
NOV	6.1	35.1	.60		11.0	4.2	41.0	.66		8.35
DEC	6.3	27.2	.65		10.4	4.7	32.0	.72		7.6

LATITUDE = 44° 03' N

LONGITUDE = 103° 04' W

ELEVATION = 3162 ft.

*Extreme conditions given in knots

TABLE 77

WEATHER INFORMATION FOR Knoxville, Tennessee (13891)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	2.4	40.5	.74		8.6	5.5	46.0	.775		6.05
FEB	6.7	42.5	.69		9.0	5.0	47.0	.725		6.4
MAR	6.5	49.4	.66		9.6	4.3	52.0	.70		7.2
APR	6.0	59.0	.63		9.7	4.4	62.7	.68		6.6
MAY	6.0	67.4	.67		7.7	4.0	71.5	.72		5.3
JUNE	5.5	75.8	.69		7.0	4.2	76.0	.77		4.6
JULY	5.7	78.4	.71		6.5	4.2	79.0	.77		4.65
AUG	5.5	77.0	.72		5.7	3.4	78.0	.795		4.2
SEPT	5.2	72.1	.71		6.1	3.2	74.0	.77		4.2
OCT	4.9	60.3	.72		6.0	2.0	62.7	.773		4.25
NOV	5.8	48.4	.70		7.4	3.7	50.7	.73		5.2
DEC	6.7	41.0	.71		7.7	5.1	43.5	.76		5.45

LATITUDE = 35° 49' N

LONGITUDE = 83° 59' W

ELEVATION = 950 ft.

*Extreme conditions given in knots

TABLE 78

WEATHER INFORMATION FOR Memphis, Tennessee (13893)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.9	41.5	.73		10.7	5.0	46.0	.77		7.5
FEB	6.4	44.1	.70		10.6	4.3	49.5	.74		7.35
MAR	6.3	51.1	.66		11.4	4.0	56.3	.687		8.8
APR	6.1	61.4	.65		11.0	4.2	66.0	.665		8.2
MAY	5.9	70.3	.68		9.1	3.5	74.0	.72		6.8
JUNE	5.4	78.5	.69		8.1	3.3	82.0	.76		6.4
JULY	5.7	81.3	.70		7.7	3.7	83.0	.76		5.3
AUG	5.0	80.5	.70		7.1	3.0	81.5	.75		4.7
SEPT	4.8	73.9	.71		7.7	2.2	75.5	.76		5.4
OCT	4.3	63.1	.68		7.8	1.5	65.5	.73		5.2
NOV	5.5	50.1	.69		9.4	3.0	53.5	.72		6.5
DEC	6.3	42.5	.72		10.0	4.2	46.0	.72		7.4

LATITUDE = 35° 03'N

LONGITUDE = 89° 59'W

ELEVATION = 258 ft.

*Extreme conditions given in knots

TABLE 79

WEATHER INFORMATION FOR Nashville, Tennessee (13897)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	7.1	39.0	.71		9.0	5.3	45.0	.815		6.35
FEB	6.7	41.0	.63		9.2	4.7	46.3	.77		6.4
MAR	6.5	49.5	.60		9.9	5.0	53.0	.735		7.2
APR	6.2	59.5	.64		9.4	5.0	63.5	.70		7.0
MAY	5.9	68.3	.68		7.5	4.0	70.8	.73		4.9
JUNE	5.5	76.3	.69		6.7	4.0	78.0	.76		4.4
JULY	5.7	79.4	.75		6.2	4.0	81.0	.773		3.7
AUG	5.3	78.3	.76		5.9	3.0	79.5	.78		3.9
SEPT	5.0	72.2	.76		6.2	2.7	74.0	.78		4.0
OCT	4.6	61.0	.66		6.3	1.5	63.0	.78		4.35
NOV	5.9	48.9	.68		8.2	3.7	51.0	.738		5.4
DEC	6.7	41.0	.69		8.6	4.7	44.5	.77		6.2

LATITUDE = 36° 07' N

LONGITUDE = 86° 41' W

ELEVATION = 590 ft.

*Extreme conditions given in knots

TABLE 80

WEATHER INFORMATION FOR Brownsville, Texas (12919)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.6	61.4	.79		11.9	4.2	66.0	.833		9.0
FEB	6.5	64.0	.78		12.6	4.0	67.5	.84		9.8
MAR	6.7	67.9	.76		13.7	5.0	70.0	.81		10.4
APR	6.6	73.9	.72		14.5	5.0	76.0	.80		11.6
MAY	5.9	79.0	.78		13.9	3.7	79.8	.80		10.6
JUNE	5.2	82.7	.77		12.8	3.5	82.8	.79		9.2
JULY	4.7	84.0	.75		11.8	2.3	83.9	.77		8.85
AUG	4.8	84.1	.75		11.0	2.0	84.0	.767		7.85
SEPT	5.2	81.2	.77		9.8	3.1	82.3	.82		7.6
OCT	4.7	75.9	.77		9.9	1.3	76.7	.775		7.6
NOV	5.8	67.6	.77		11.0	1.7	69.5	.82		7.8
DEC	6.6	62.9	.79		11.1	4.2	64.7	.83		8.8

LATITUDE = 25° 54' N

LONGITUDE = 97° 26' W

ELEVATION = 16 ft.

*Extreme conditions given in knots

TABLE 81

WEATHER INFORMATION FOR Dallas, Texas (13960)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.3	45.7	.70		10.2	3.0	50.0	.76		7.6
FEB	6.1	49.8	.68		10.9	3.0	53.7	.74		8.0
MAR	5.8	57.4	.62		12.7	4.0	61.0	.68		10.0
APR	6.0	66.3	.66		13.1	3.5	70.5	.68		9.8
MAY	5.8	73.7	.68		11.9	4.1	76.5	.72		8.6
JUNE	4.6	81.9	.65		12.3	2.5	83.5	.69		9.2
JULY	4.3	85.5	.61		9.9	2.3	88.5	.67		7.2
AUG	4.0	85.8	.58		9.6	2.0	88.0	.66		6.8
SEPT	4.0	78.9	.62		9.1	1.7	80.0	.73		6.5
OCT	4.4	68.8	.64		9.1	1.5	71.0	.70		6.7
NOV	4.6	55.8	.64		10.1	2.5	59.0	.72		6.5
DEC	5.6	48.3	.67		10.1	4.0	51.0	.707		7.6

LATITUDE = 32° 51' N

LONGITUDE = 96° 51' W

ELEVATION = 476 ft.

*Extreme conditions given in knots

TABLE 82

WEATHER INFORMATION FOR El Paso, Texas (23044)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	4.7	43.4	.50		10.4	1.7	49.5	.60		6.1
FEB	4.2	49.1	.40		11.3	2.4	53.0	.45		7.3
MAR	4.5	54.5	.32		13.2	2.3	59.0	.43		8.1
APR	3.8	63.1	.29		13.0	2.0	67.7	.32		8.4
MAY	3.3	71.6	.27		12.4	1.3	75.7	.30		8.0
JUNE	3.0	80.2	.30		11.4	1.0	84.5	.355		6.6
JULY	4.7	81.3	.43		10.1	3.0	84.5	.505		5.55
AUG	4.1	79.8	.46		9.6	2.0	83.0	.50		5.6
SEPT	3.0	74.9	.42		9.4	1.0	78.3	.555		5.2
OCT	3.3	65.2	.44		9.4	1.1	68.0	.52		4.6
NOV	3.2	52.0	.43		10.0	1.2	55.0	.52		5.45
DEC	4.1	44.8	.47		9.9	2.3	48.0	.60		5.25

LATITUDE = 31° 48' N

LONGITUDE = 106° 24' W

ELEVATION = 3920 ft.

*Extreme conditions given in knots

TABLE 83

WEATHER INFORMATION FOR Houston, Texas (12918)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.6	53.8	.77		10.8	5.0	59.0	.80		8.8
FEB	6.7	57.7	.77		11.2	4.3	61.0	.82		8.6
MAR	6.4	62.6	.72		11.6	5.3	65.5	.755		9.6
APR	6.4	69.5	.76		12.0	4.5	72.0	.78		9.65
MAY	6.2	75.9	.77		10.7	4.2	76.7	.78		8.3
JUNE	5.5	81.8	.76		9.7	3.7	82.0	.795		7.1
JULY	5.9	83.8	.76		8.3	4.0	83.5	.785		6.55
AUG	5.7	84.2	.77		8.3	3.5	83.0	.78		5.8
SEPT	5.4	80.0	.76		8.8	3.2	79.3	.80		6.3
OCT	4.7	72.6	.75		9.3	2.0	72.0	.82		6.8
NOV	5.6	61.9	.74		10.3	4.0	63.8	.795		7.4
DEC	6.2	55.8	.77		10.2	5.0	57.7	.80		8.15

LATITUDE = 29° 46' N

LONGITUDE = 95° 22' W

ELEVATION = 41 ft.

*Extreme conditions given in knots

TABLE 84

WEATHER INFORMATION FOR Salt Lake City, Utah (24127)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.9	26.5	.76		7.5	5.2	34.0	.79		5.15
FEB	7.0	33.4	.71		8.2	5.2	38.0	.76		5.2
MAR	6.5	41.1	.61		9.2	5.0	43.0	.695		6.3
APR	6.1	50.1	.53		9.4	4.7	53.0	.58		7.2
MAY	5.4	58.9	.48		9.5	4.0	62.0	.543		6.2
JUNE	4.2	67.1	.44		9.4	2.2	71.7	.52		6.0
JULY	3.5	76.6	.38		9.5	2.0	80.0	.42		6.0
AUG	3.4	74.4	.38		9.6	2.1	77.3	.47		6.2
SEPT	3.4	64.2	.42		9.0	1.3	67.0	.52		5.9
OCT	4.3	52.9	.54		8.5	2.2	56.0	.58		5.5
NOV	5.6	39.3	.68		7.6	3.4	44.0	.71		5.3
DEC	6.9	31.5	.76		7.4	5.0	35.5	.797		4.5

LATITUDE = 40° 46' N

LONGITUDE = 111° 58' W

ELEVATION = 4220 ft.

*Extreme conditions given in knots

TABLE 85

WEATHER INFORMATION FOR Burlington, Vermont

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND
JAN	7.5	16.2	.74		9.9					
FEB	7.2	17.4	.73		9.6					
MAR	7.0	26.7	.70		9.4					
APR	7.2	41.2	.67		9.6					
MAY	6.9	53.8	.67		9.1					
JUNE	6.6	64.2	.70		8.4					
JULY	6.3	69.0	.70		7.8					
AUG	6.1	66.7	.73		7.5					
SEPT	6.2	58.4	.76		8.3					
OCT	6.5	47.6	.74		8.6					
NOV	8.1	35.3	.76		9.7					
DEC	7.9	21.5	.76		10.0					

LATITUDE = 44° 28' N

LONGITUDE = 73° 12' W

ELEVATION = 331 ft.

TABLE 86

WEATHER INFORMATION FOR Norfolk, Virginia (13737)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.2	41.2	.70		11.7	5.0	46.0	.735		8.6
FEB	6.2	41.6	.68		12.0	4.5	46.0	.76		9.15
MAR	6.0	48.0	.66		12.5	4.3	52.0	.68		9.8
APR	6.0	58.0	.66		11.9	4.3	61.0	.71		8.8
MAY	6.1	67.5	.71		10.2	4.4	69.0	.74		7.8
JUNE	5.6	75.6	.72		9.4	3.3	76.0	.75		6.93
JULY	6.0	78.8	.75		8.7	4.3	79.7	.785		6.7
AUG	5.9	77.5	.78		8.8	4.1	78.7	.80		6.5
SEPT	5.7	72.6	.76		9.7	3.0	73.0	.785		6.8
OCT	5.1	62.0	.76		10.4	2.0	64.0	.80		7.4
NOV	5.3	51.4	.71		10.8	3.0	54.0	.74		7.95
DEC	6.0	42.5	.69		10.9	4.0	46.0	.72		8.4

LATITUDE = 36° 54' N

LONGITUDE = 76° 12' W

ELEVATION = 22 ft.

*Extreme conditions given in knots

TABLE 87

WEATHER INFORMATION FOR Roanoke, Virginia (13741)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.3	38.1	.64		10.0	4.2	42.0	.68		7.5
FEB	6.4	39.2	.62		10.4	4.3	43.0	.66		7.2
MAR	6.3	45.5	.59		10.8	4.2	49.0	.61		8.2
APR	6.2	56.4	.57		10.4	4.3	59.5	.605		7.6
MAY	6.1	65.7	.64		8.0	5.0	68.0	.685		6.0
JUNE	5.9	73.4	.68		6.8	4.3	73.5	.715		4.85
JULY	6.0	76.6	.70		6.6	4.4	77.3	.75		4.4
AUG	6.0	75.4	.72		6.2	4.1	75.7	.76		4.6
SEPT	5.5	69.1	.73		5.9	3.4	70.0	.76		3.5
OCT	4.8	58.2	.68		6.7	1.0	59.8	.74		4.9
NOV	5.7	46.7	.63		8.6	3.3	49.0	.648		6.2
DEC	6.0	38.4	.62		9.2	4.0	41.0	.655		6.35

LATITUDE = 37° 19' N

LONGITUDE = 79° 58' W

ELEVATION = 1149 ft.

*Extreme conditions given in knots

TABLE 88

WEATHER INFORMATION FOR Seattle, Washington (24233)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	8.5	38.3	.80		10.4	6.7	42.5	.88		6.4
FEB	8.2	40.8	.75		10.4	6.0	47.0	.828		7.0
MAR	8.0	43.8	.74		10.6	5.5	45.0	.808		7.0
APR	7.7	49.2	.74		10.2	6.1	49.5	.77		5.7
MAY	7.2	55.5	.70		9.5	5.3	56.8	.76		5.8
JUNE	7.0	59.8	.68		9.2	4.5	62.0	.75		5.4
JULY	5.3	64.9	.67		8.7	3.7	66.5	.73		4.85
AUG	5.8	64.1	.70		8.3	3.5	66.0	.76		4.9
SEPT	6.2	59.9	.76		8.5	4.1	61.5	.797		4.8
OCT	7.7	52.4	.81		9.3	5.7	53.7	.86		5.9
NOV	8.4	43.9	.81		9.6	6.3	48.3	.873		5.6
DEC	8.8	40.8	.82		10.4	7.3	44.0	.885		6.45

LATITUDE = 47° 27' N

LONGITUDE = 122° 18' W

ELEVATION = 400 ft.

*Extreme conditions given in knots

TABLE 89

WEATHER INFORMATION FOR Spokane, Washington (24157)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	8.1	24.9	.82		8.0	6.3	32.0	.86		5.0
FEB	8.0	29.7	.79		8.7	6.0	36.5	.825		6.2
MAR	7.4	38.1	.69		9.2	5.3	39.0	.745		6.0
APR	6.9	46.3	.58		9.1	5.1	49.5	.66		6.5
MAY	6.5	54.7	.58		8.1	5.0	59.0	.68		6.1
JUNE	6.3	61.4	.56		8.4	4.1	64.0	.585		6.1
JULY	3.3	69.6	.44		7.8	1.3	72.7	.44		5.5
AUG	4.0	67.9	.44		7.6	2.0	73.5	.517		5.5
SEPT	4.9	59.2	.51		7.6	2.5	64.0	.60		5.3
OCT	6.6	48.6	.70		7.4	4.2	50.5	.80		5.6
NOV	7.7	35.7	.80		7.6	6.0	40.0	.84		5.0
DEC	8.6	29.1	.87		8.6	7.0	33.5	.88		5.16

LATITUDE = 47° 37' N

LONGITUDE = 117° 31' W

ELEVATION = 2357 ft.

*Extreme conditions given in knots

TABLE 90

WEATHER INFORMATION FOR Huntington,West Virginia

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND
JAN	6.9	36.6	.70		7.3					
FEB	6.9	37.7	.68		7.4					
MAR	7.2	44.8	.64		8.0					
APR	7.1	55.7	.62		7.5					
MAY	6.6	64.6	.70		6.2					
JUNE	6.1	72.0	.73		5.1					
JULY	6.4	75.2	.76		4.9					
AUG	6.3	74.0	.78		4.9					
SEPT	5.9	68.2	.78		4.8					
OCT	5.1	57.3	.70		5.5					
NOV	7.0	45.5	.73		6.7					
DEC	7.5	37.4	.75		7.2					

LATITUDE = 38° 22' N

LONGITUDE = 82° 33' W

ELEVATION = 827 ft.

TABLE 91

WEATHER INFORMATION FOR Green Bay, Wisconsin (14898)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.7	16.1	.75		11.1	5.0	21.0	.801		7.69
FEB	6.3	17.3	.76		11.0	4.3	25.1	.811		7.39
MAR	6.3	28.5	.74		11.7	5.2	33.1	.791		7.29
APR	6.7	41.8	.69		12.2	4.3	46.6	.77		8.79
MAY	6.2	54.4	.68		11.3	4.6	59.8	.721		7.99
JUNE	5.9	64.7	.72		9.9	4.3	67.0	.74		6.29
JULY	5.4	69.9	.74		8.5	4.1	70.7	.748		5.29
AUG	5.5	67.8	.76		8.2	4.0	70.1	.801		5.49
SEPT	5.6	60.2	.77		10.0	4.0	60.8	.81		6.2
OCT	6.0	48.4	.76		10.4	3.5	52.5	.80		7.0
NOV	7.1	33.5	.75		12.4	5.4	38.0	.79		8.3
DEC	7.0	20.1	.78		11.3	5.3	27.0	.82		7.9

LATITUDE = 44° 29' N

LONGITUDE = 88° 08' W

ELEVATION = 682 ft.

*Extreme conditions given in knots

TABLE 92

WEATHER INFORMATION FOR Casper, Wyoming (24089)

MO	NORMAL CONDITIONS					EXTREME CONDITIONS				
	CC	TAIR	HUM	PPT	WIND	CC	TAIR	HUM	PPT	WIND*
JAN	6.4	23.4	.60		16.9	4.6	29.2	.642		12.98
FEB	6.6	26.3	.62		15.4	4.9	31.6	.702		10.98
MAR	6.6	32.1	.62		14.4	4.5	36.4	.711		8.19
APR	6.7	43.1	.56		12.9	5.2	46.0	.631		8.4
MAY	6.7	53.1	.56		12.1	5.2	55.1	.606		8.49
JUNE	5.1	63.1	.48		11.5	3.2	66.7	.591		7.78
JULY	3.8	71.7	.41		10.3	2.2	74.6	.491		6.69
AUG	4.4	70.1	.40		10.9	2.3	71.6	.451		7.96
SEPT	4.2	59.7	.44		11.3	2.5	62.1	.571		7.88
OCT	4.9	48.3	.49		12.4	3.0	51.1	.601		8.8
NOV	6.2	33.6	.60		15.2	4.3	39.0	.681		10.99
DEC	6.1	27.3	.62		16.6	4.0	31.1	.671		11.9

LATITUDE = 42° 55' N

LONGITUDE = 106° 28' W

ELEVATION = 5338 ft.

*Extreme conditions given in knots

APPENDIX B

RESULTS OF COMPUTATIONS FOR INDIVIDUAL STATIONS

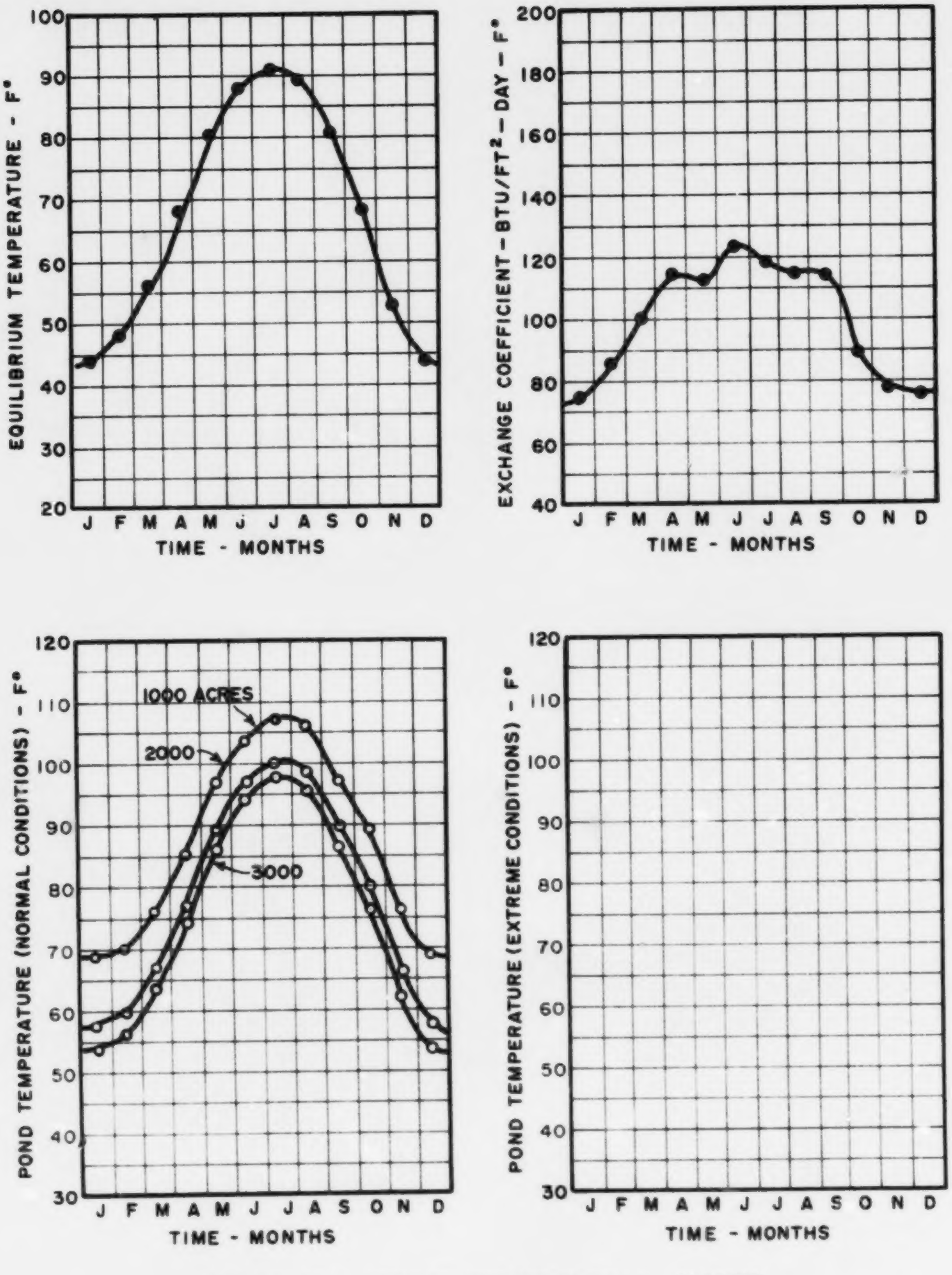

FIGURE 45 - RESULTS FOR HUNTSVILLE, ALABAMA
(AVERAGE CONDITIONS)

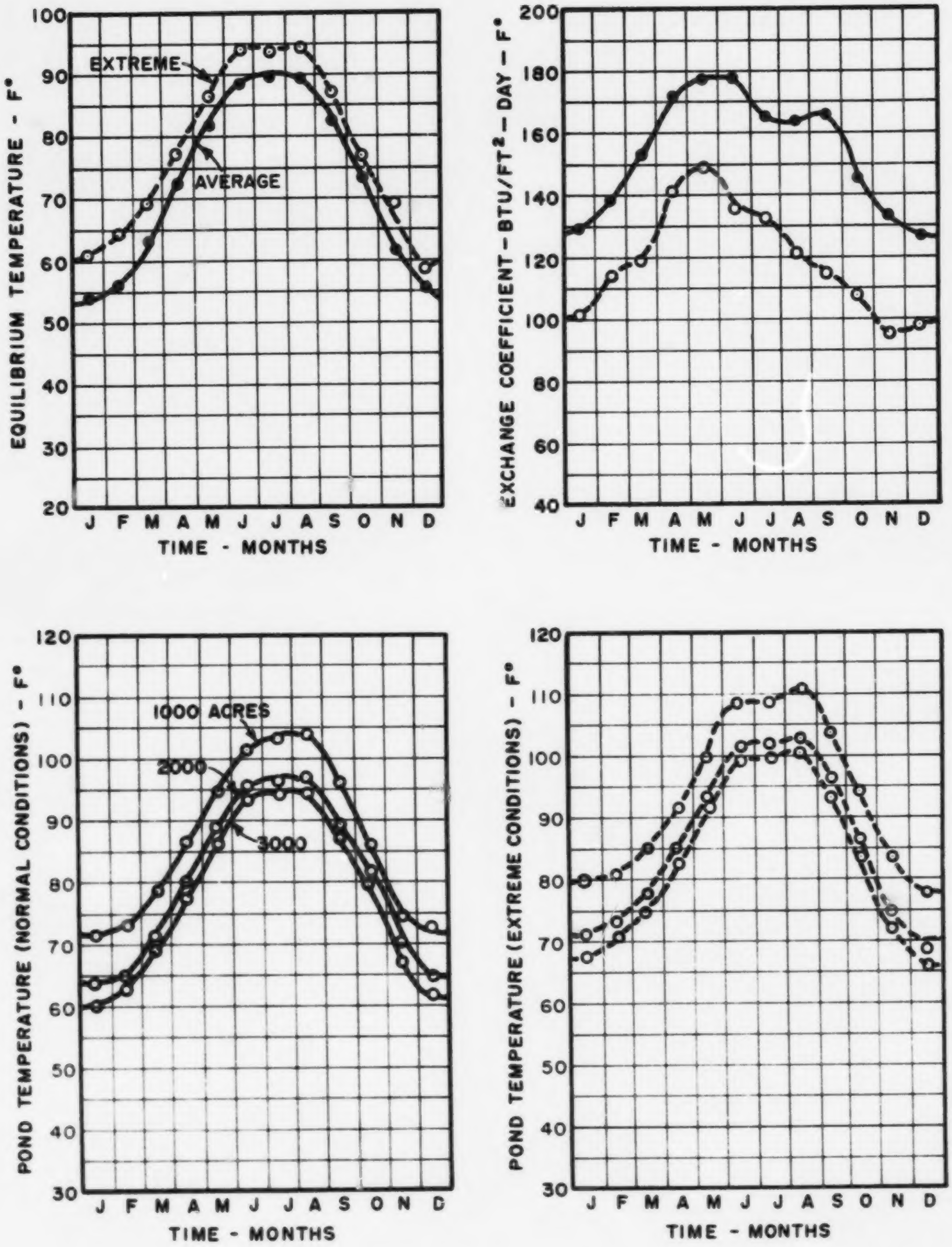

FIGURE 46 - RESULTS FOR MOBILE, ALABAMA

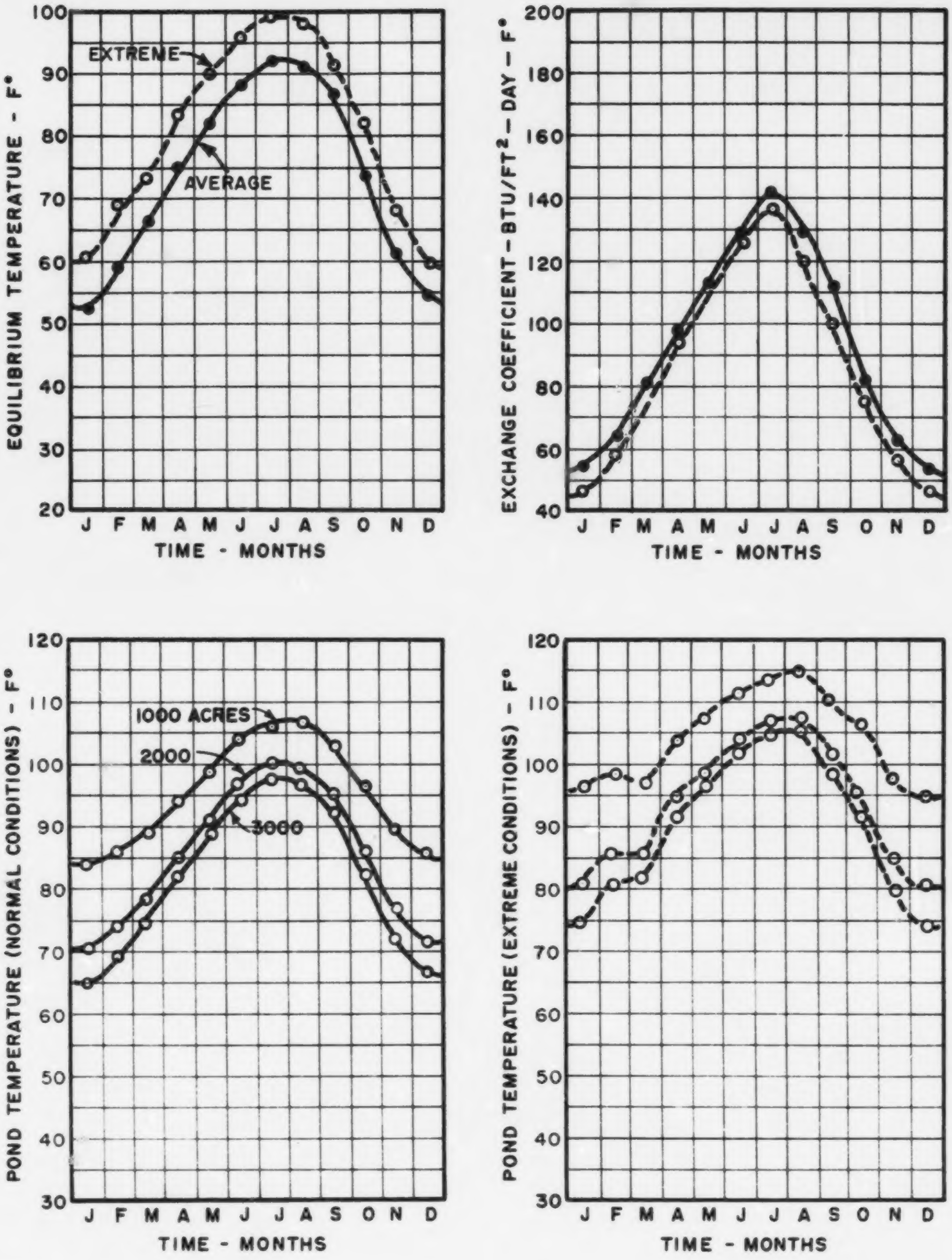

FIGURE 47 - RESULTS FOR PHOENIX, ARIZONA

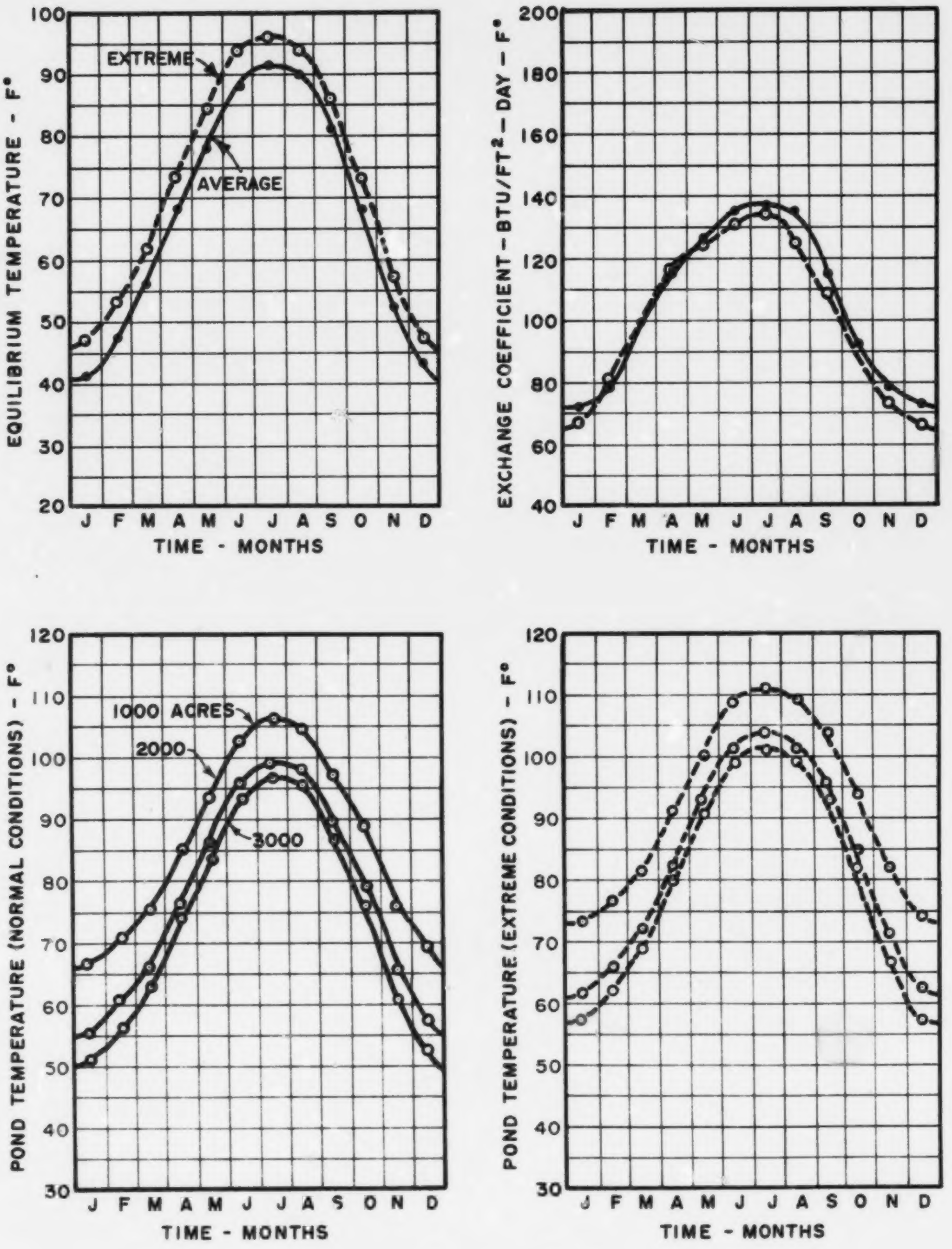

FIGURE 48 - RESULTS FOR FORT SMITH, ARKANSAS

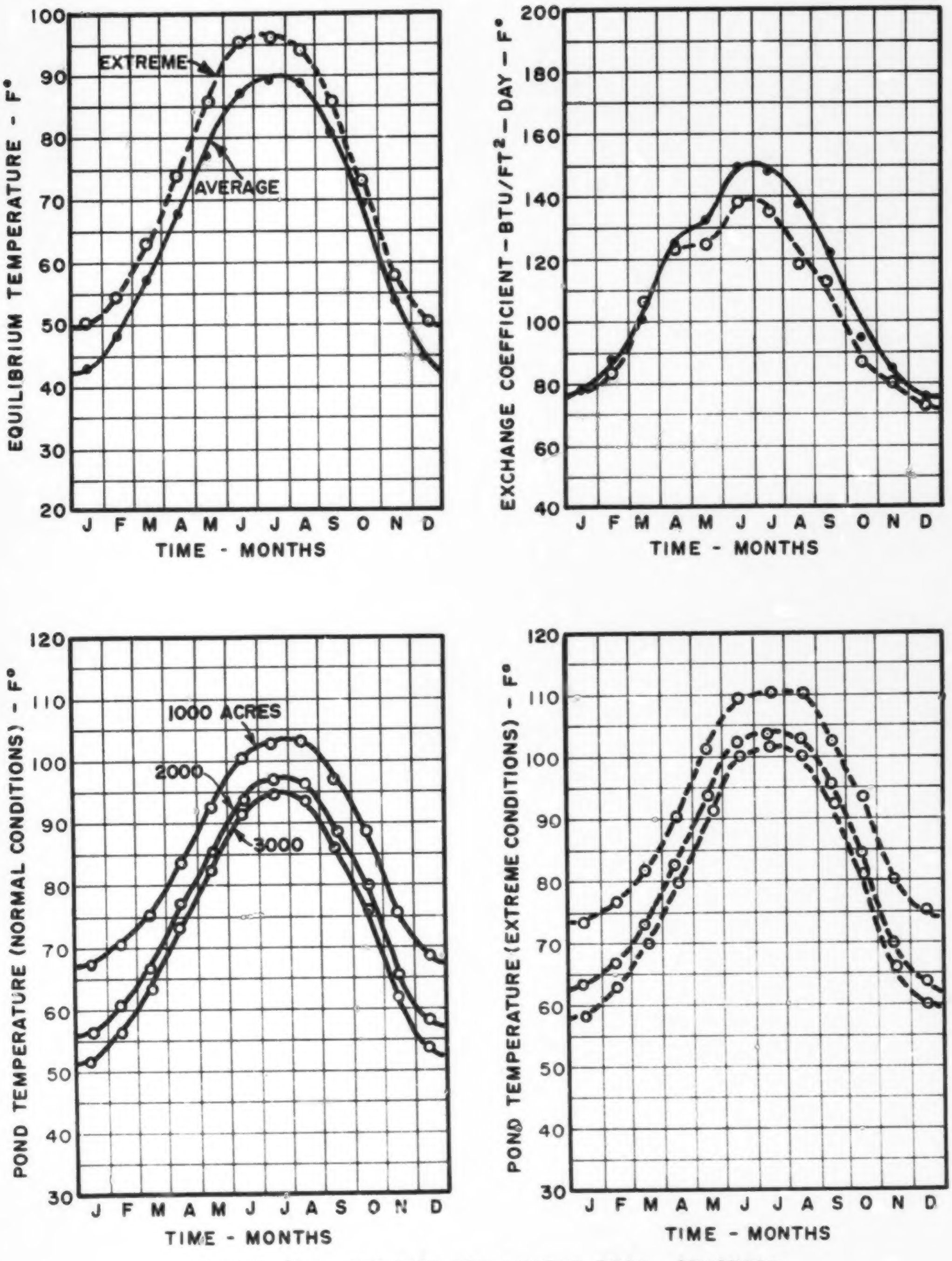

FIGURE 49 - RESULTS FOR LITTLE ROCK, ARKANSAS

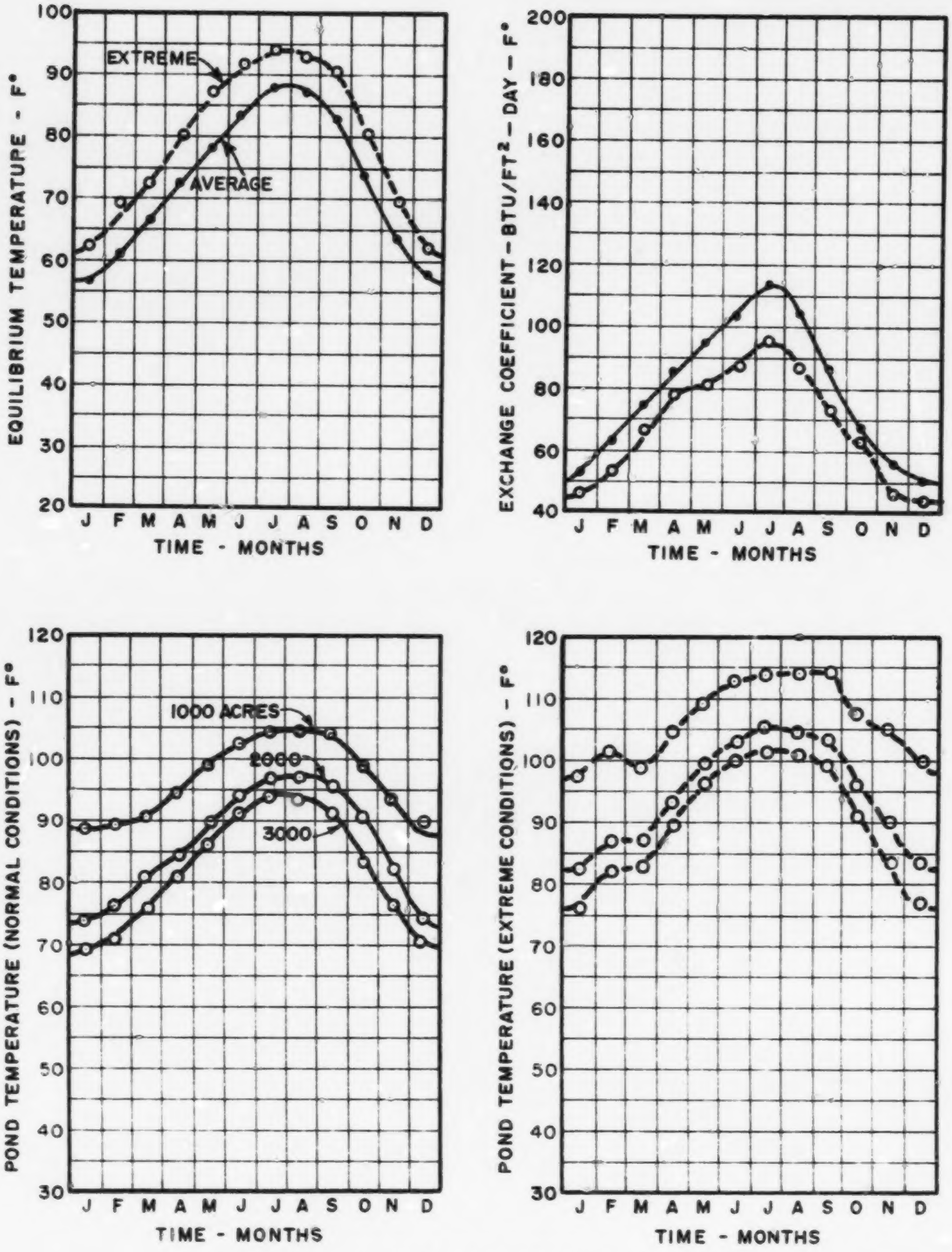

FIGURE 50 - RESULTS FOR BURBANK, CALIFORNIA

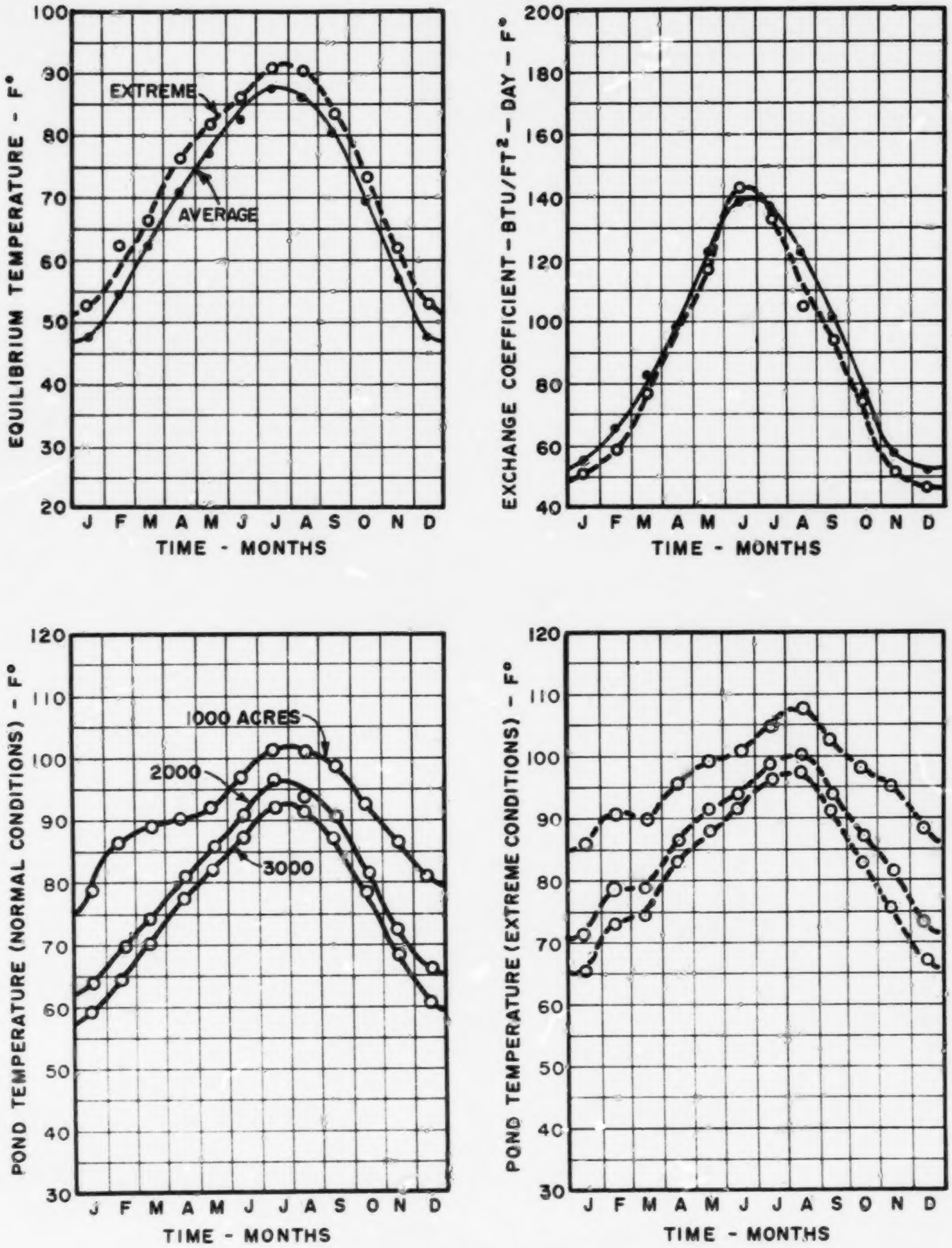

FIGURE 51 - RESULTS FOR FRESNO, CALIFORNIA

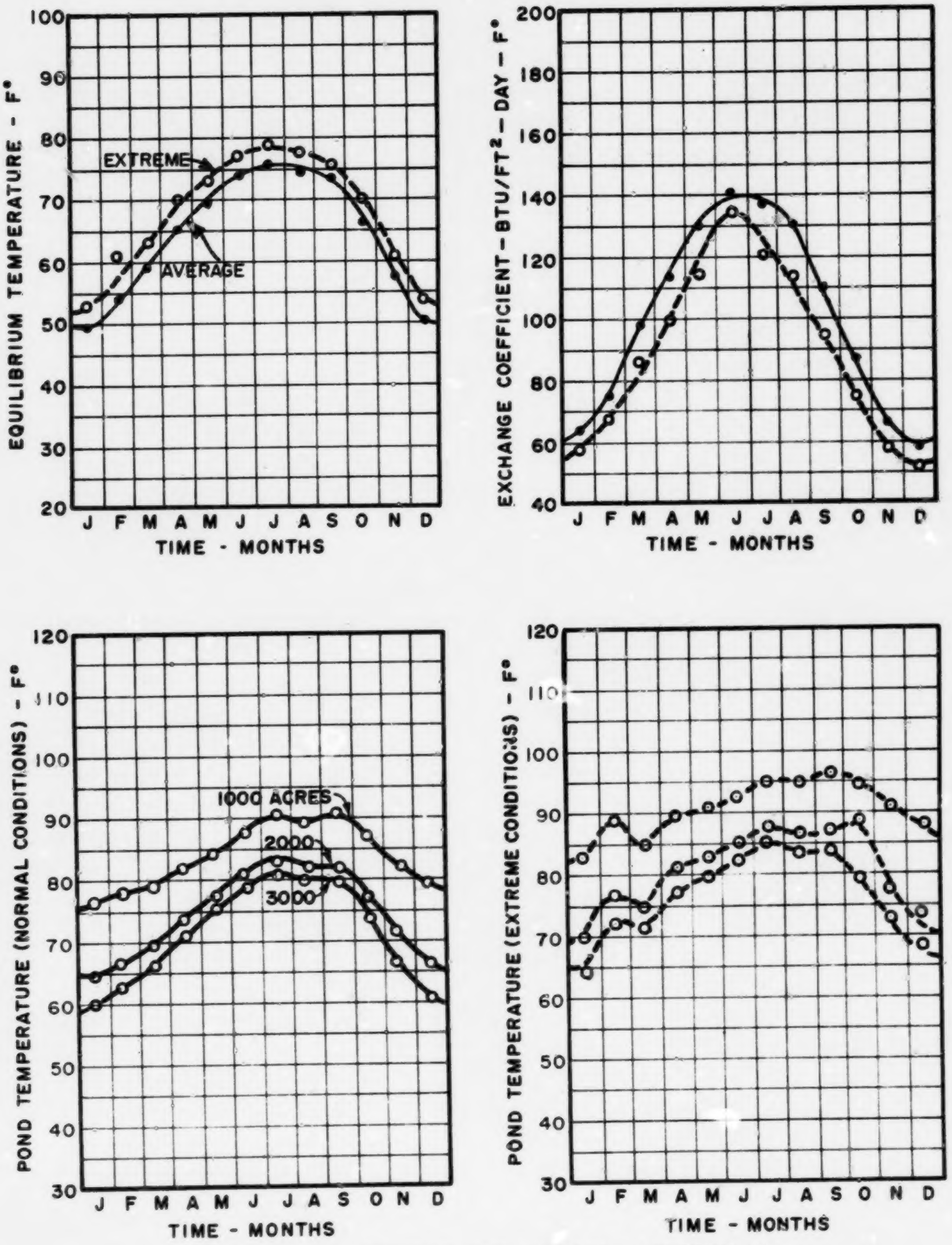

FIGURE 52 - RESULTS FOR OAKLAND, CALIFORNIA

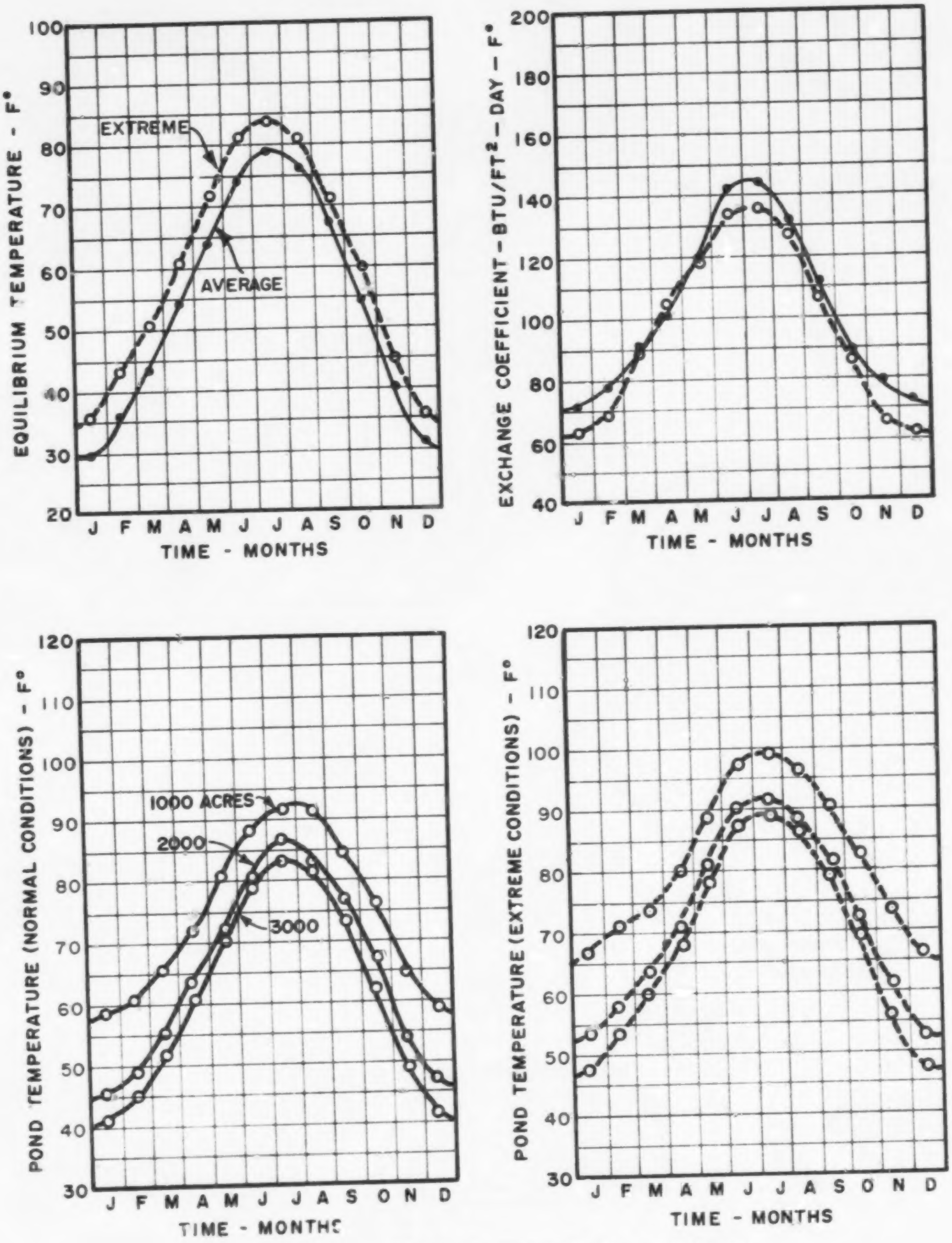

FIGURE 53 - RESULTS FOR DENVER, COLORADO

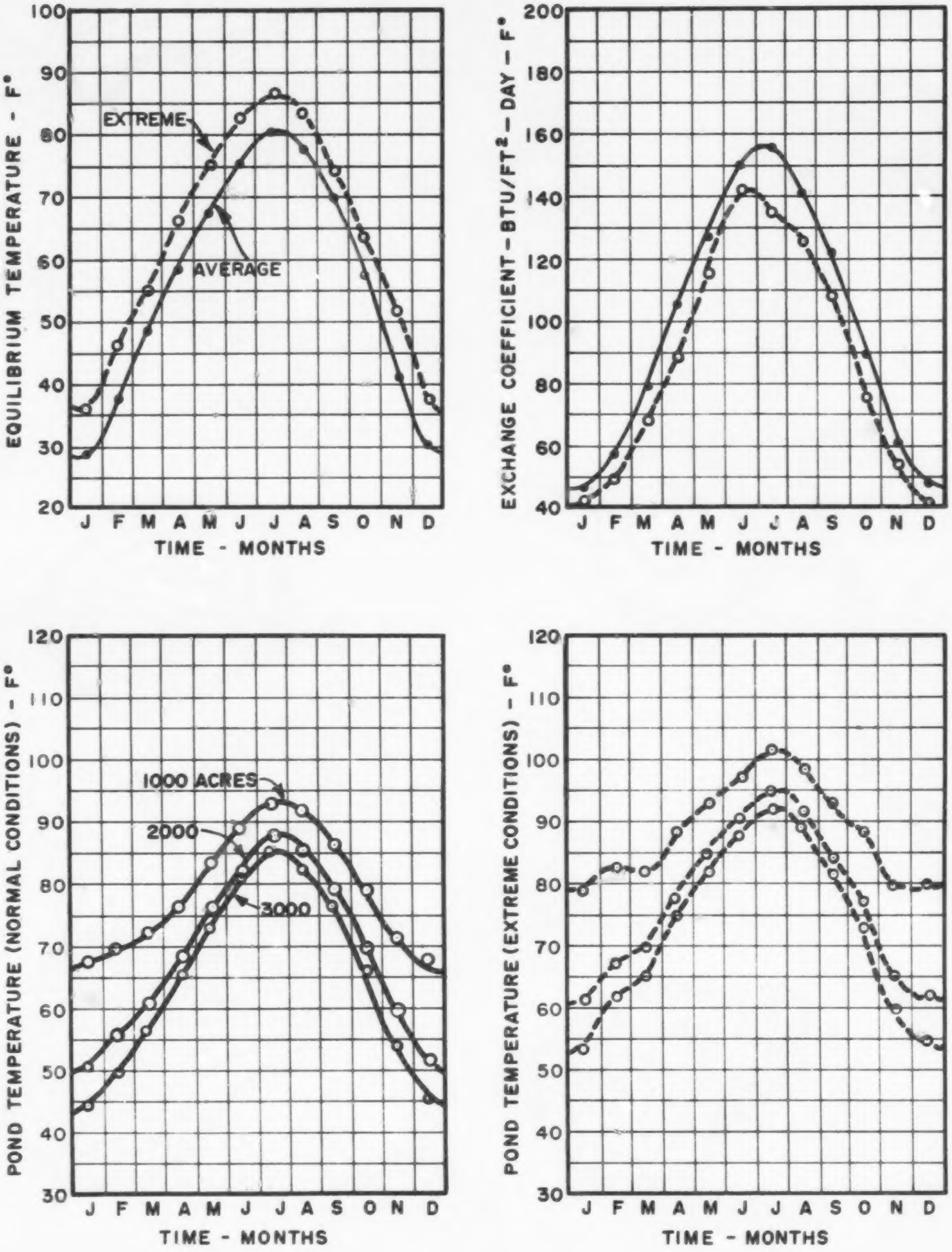

FIGURE 54 - RESULTS FOR GRAND JUNCTION, COLORADO

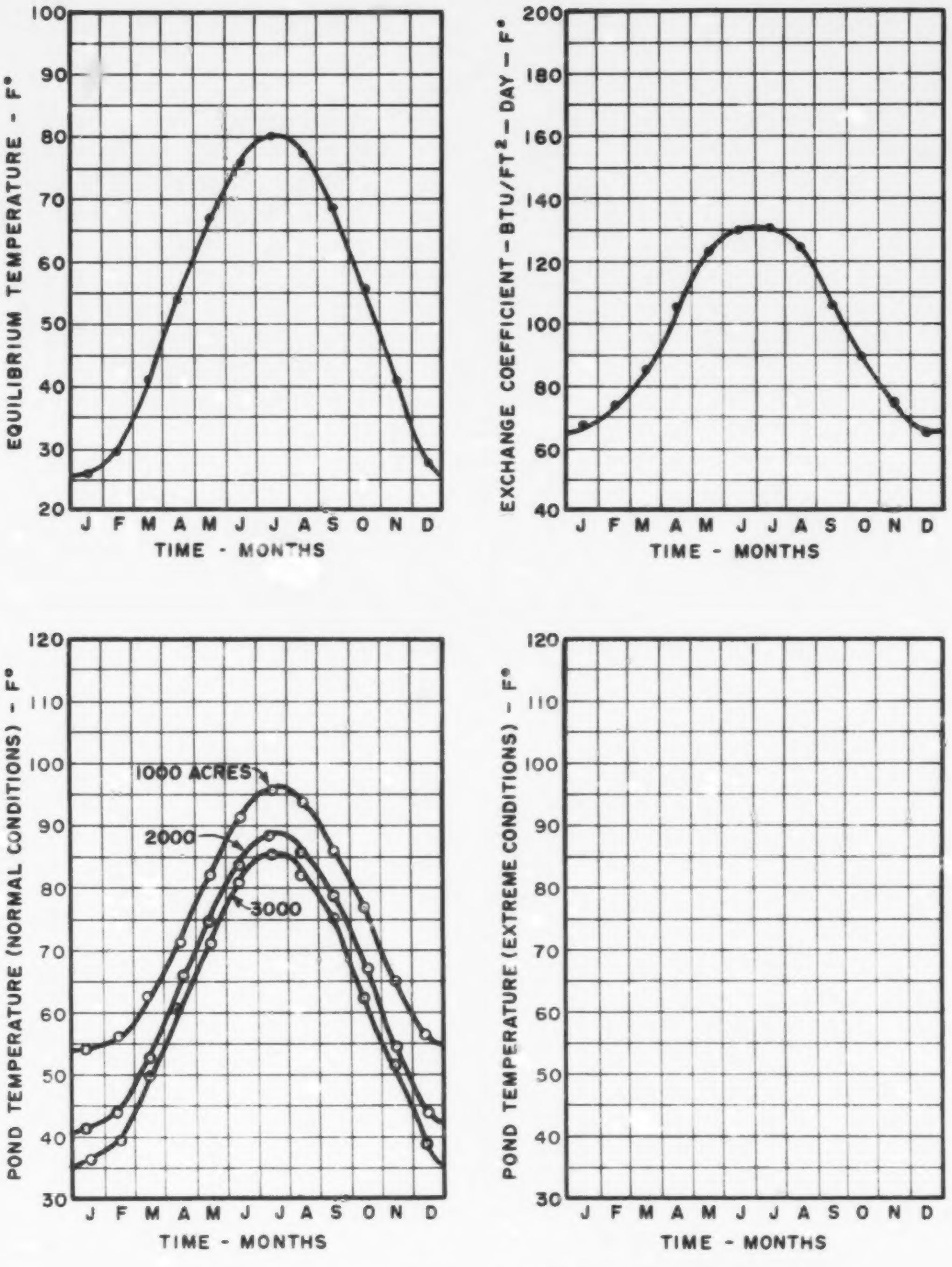

FIGURE 55 - RESULTS FOR HARTFORD, CONNECTICUT
(AVERAGE CONDITIONS)

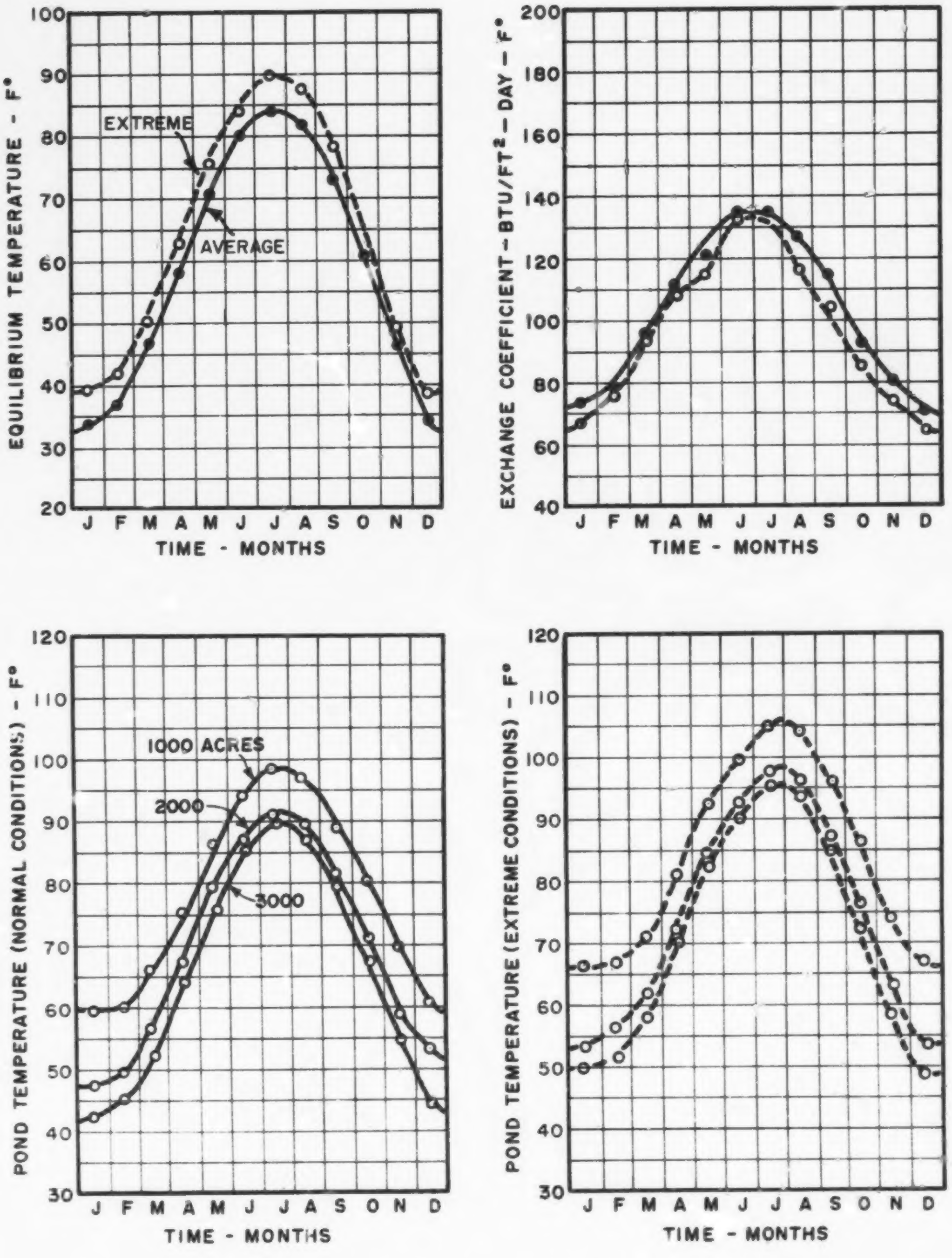

FIGURE 56 - RESULTS FOR WILMINGTON, DELAWARE

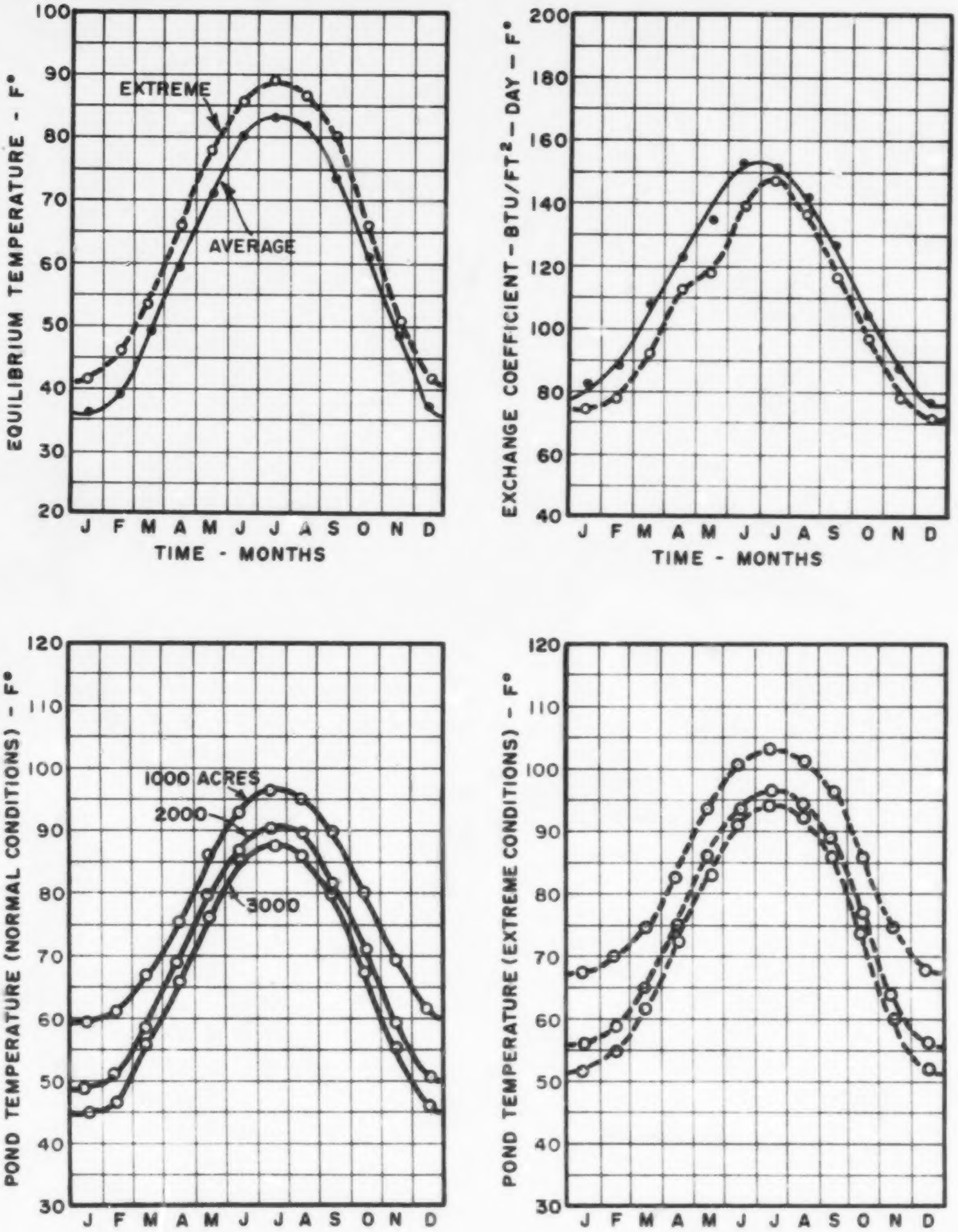

FIGURE 57 - RESULTS FOR WASHINGTON, D. C.

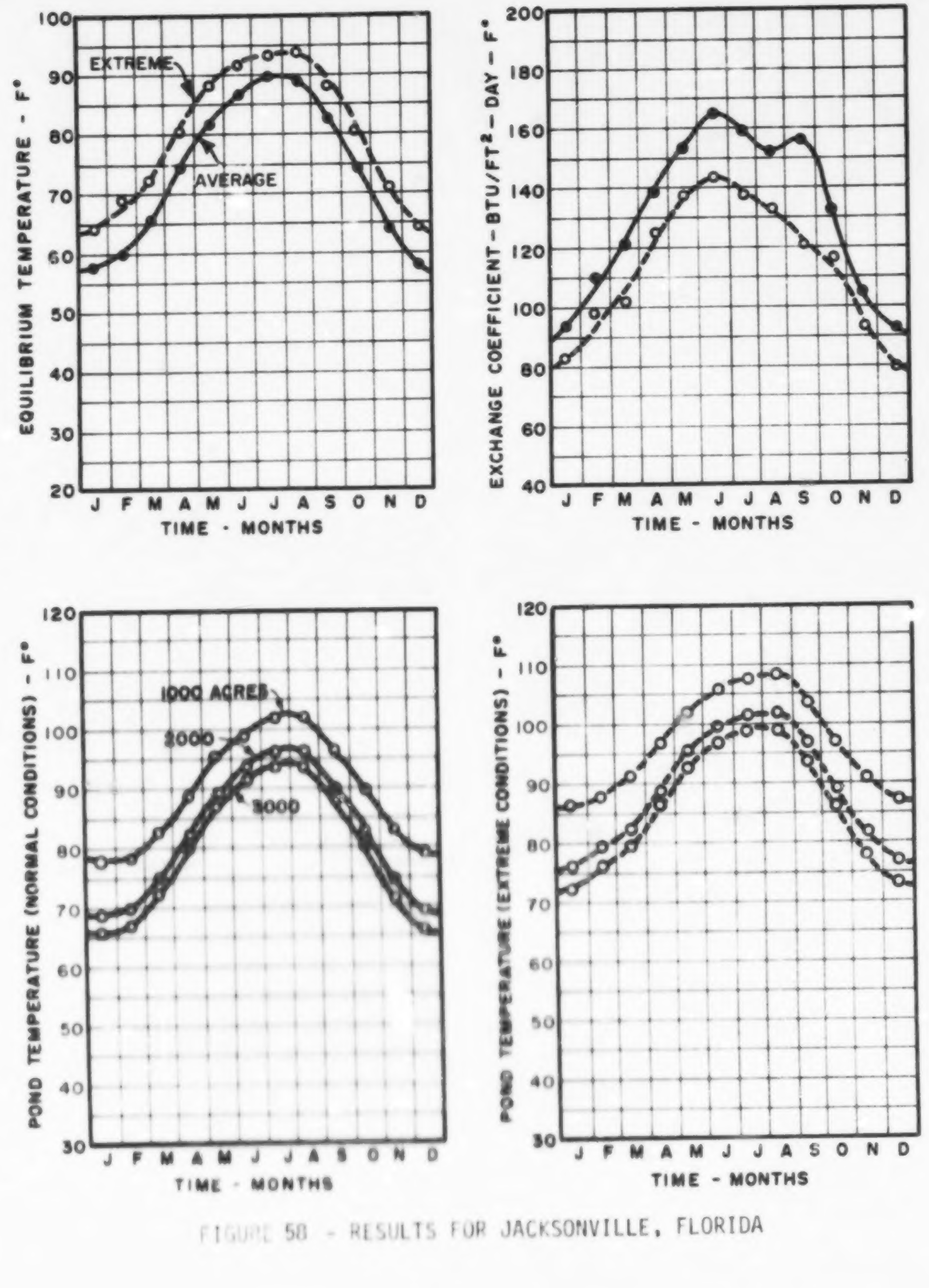

FIGURE 58 - RESULTS FOR JACKSONVILLE, FLORIDA

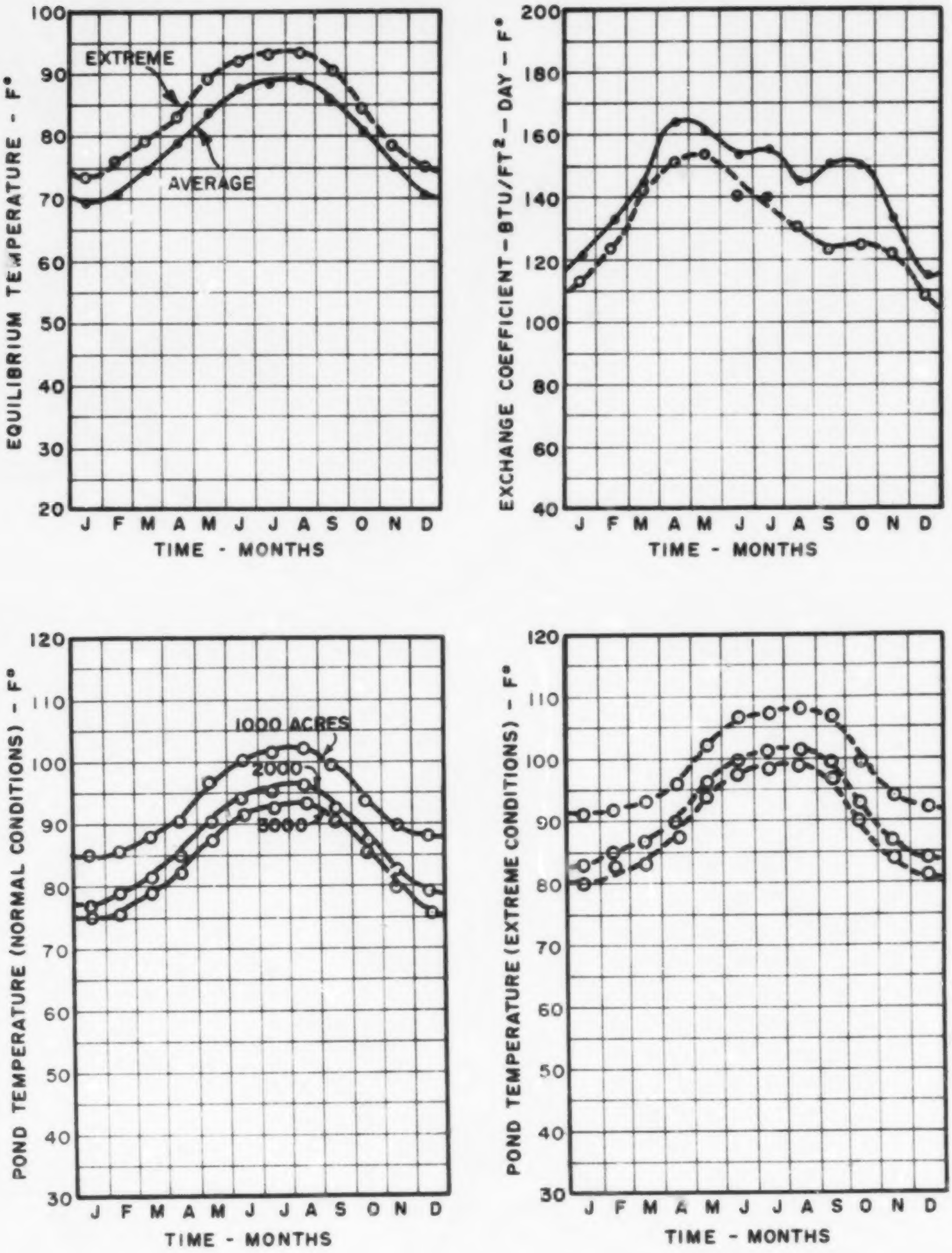

FIGURE 59 - RESULTS FOR MIAMI, FLORIDA

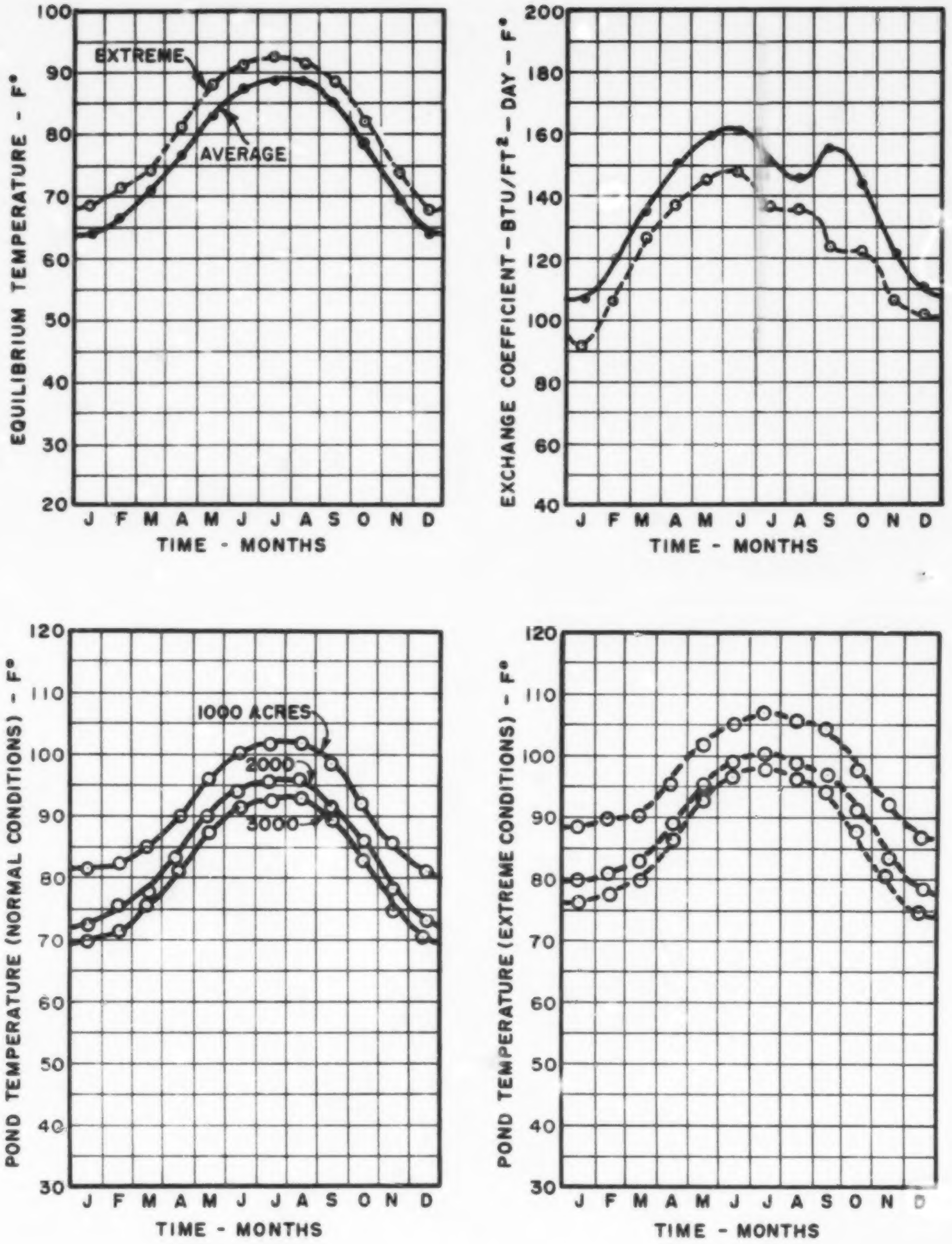

FIGURE 60 - RESULTS FOR TAMPA, FLORIDA

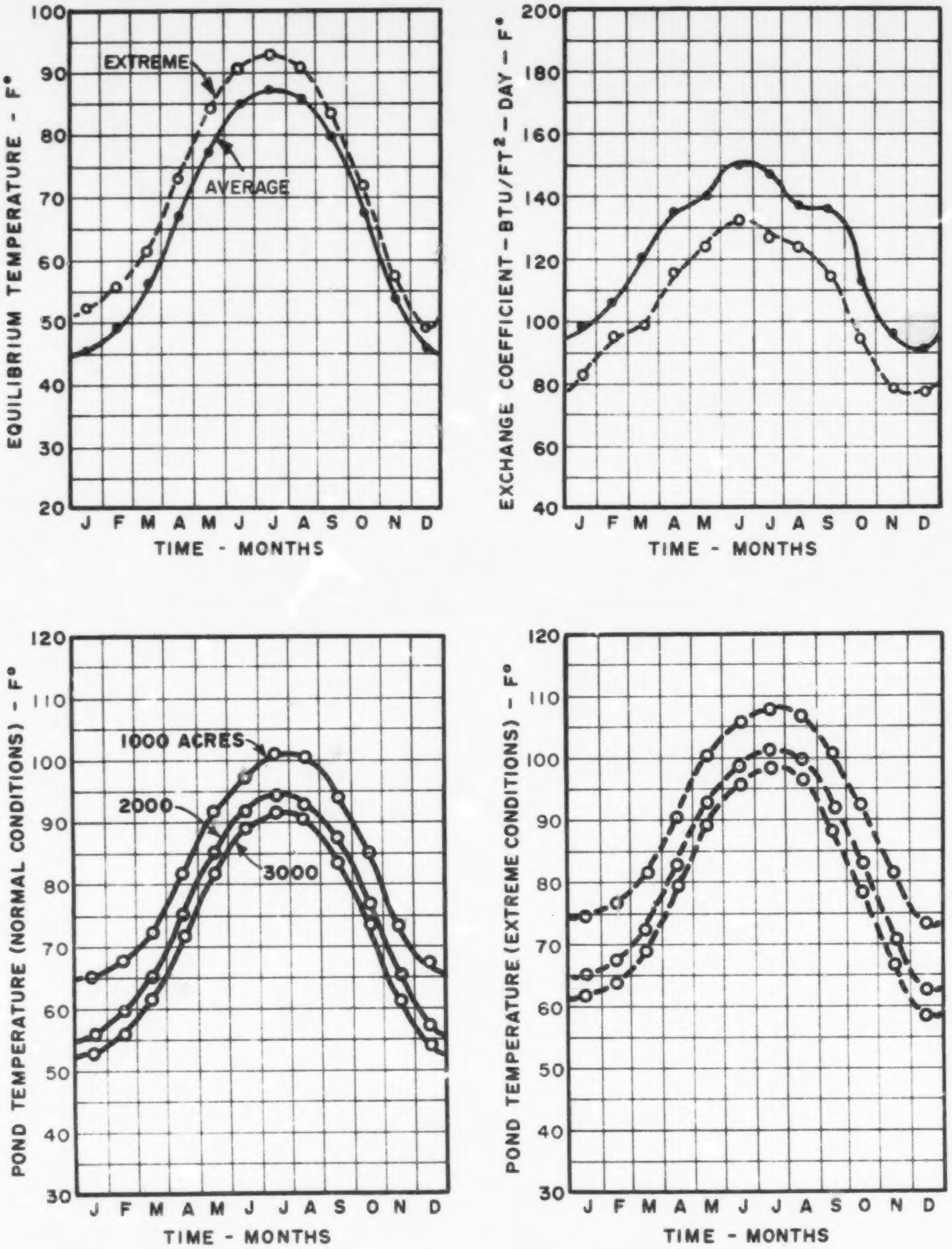

FIGURE 61 - RESULTS FOR ATLANTA, GEORGIA

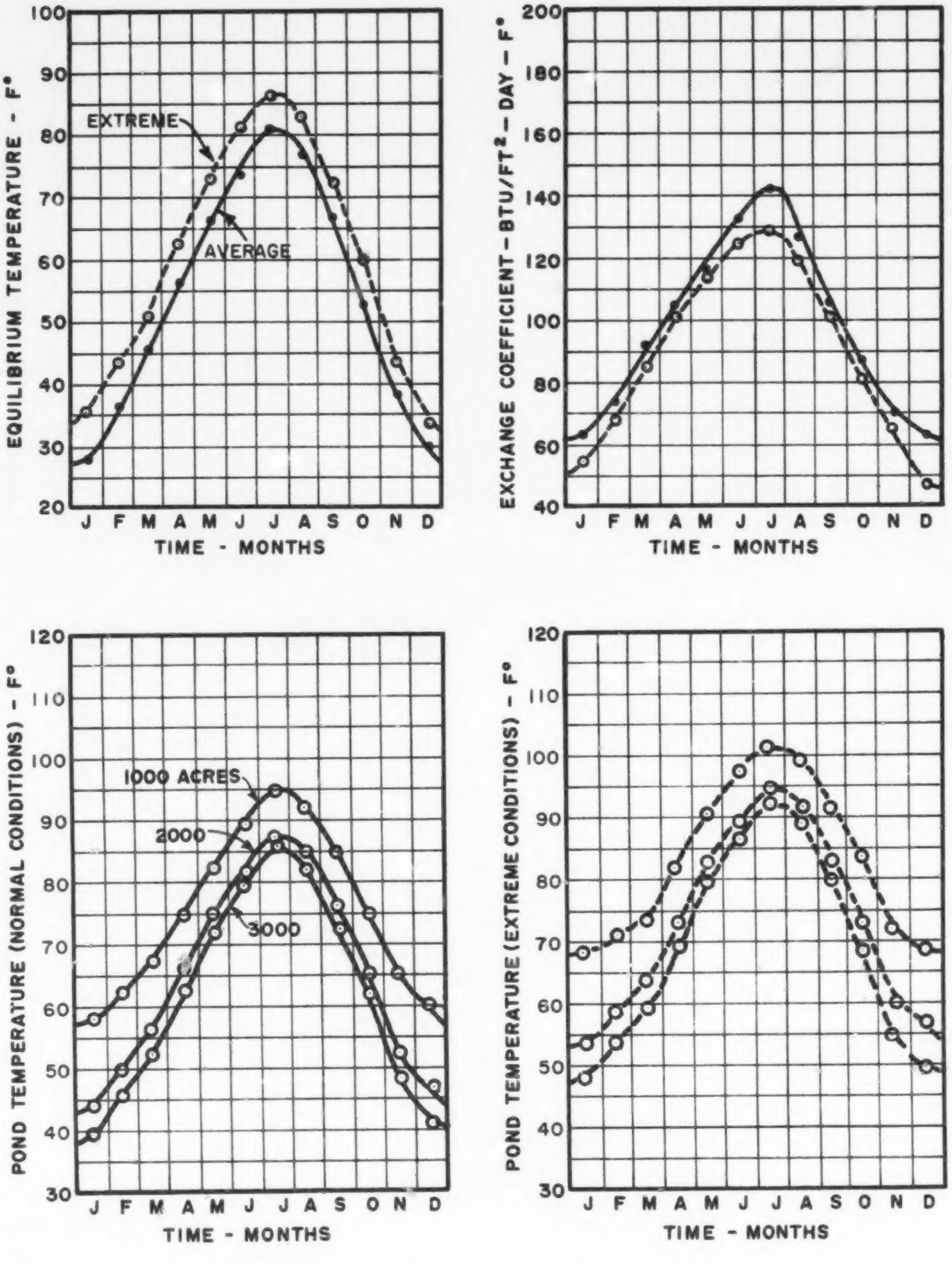

FIGURE 62 - RESULTS FOR BOISE, IDAHO

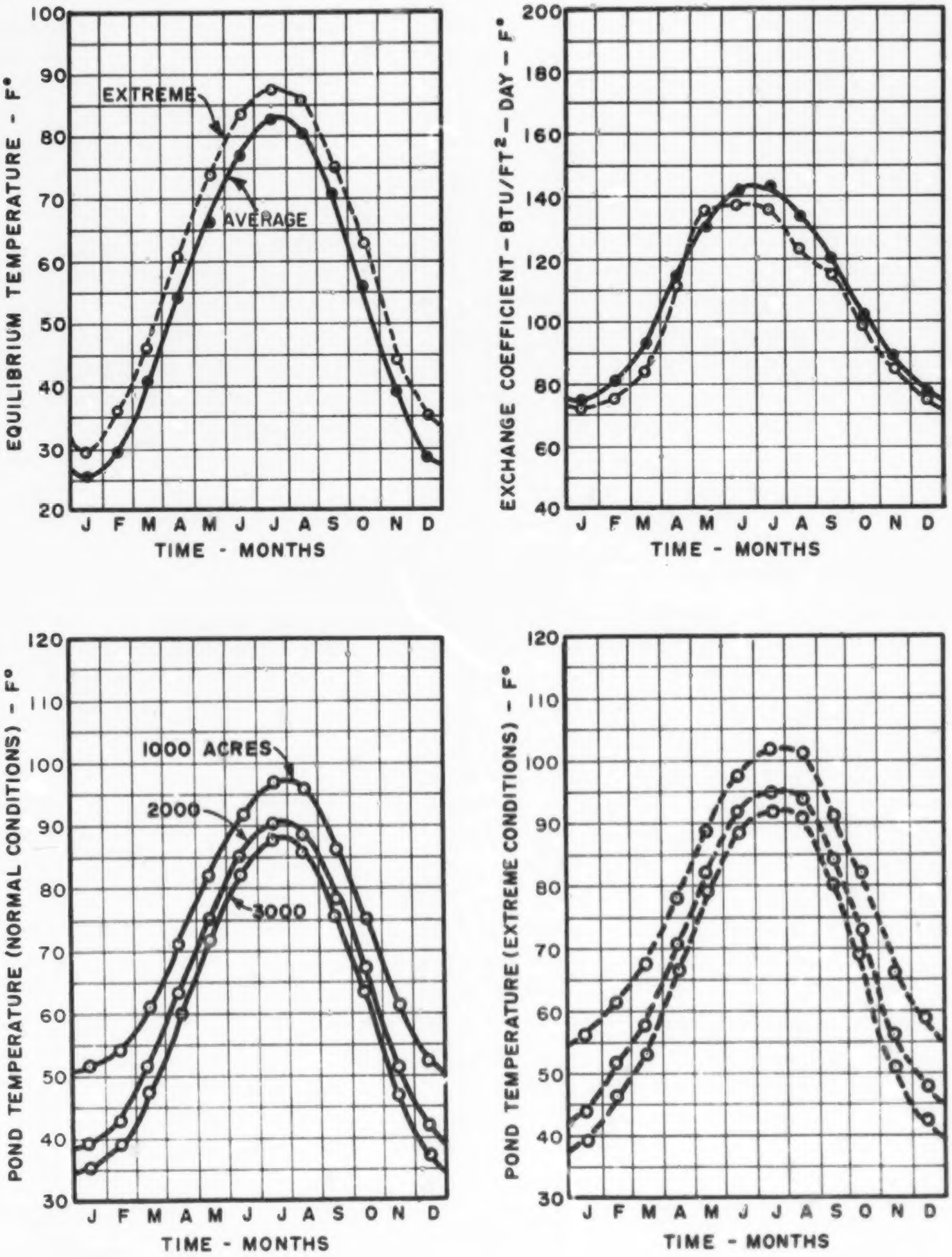

FIGURE 63 - RESULTS FOR CHICAGO, ILLINOIS

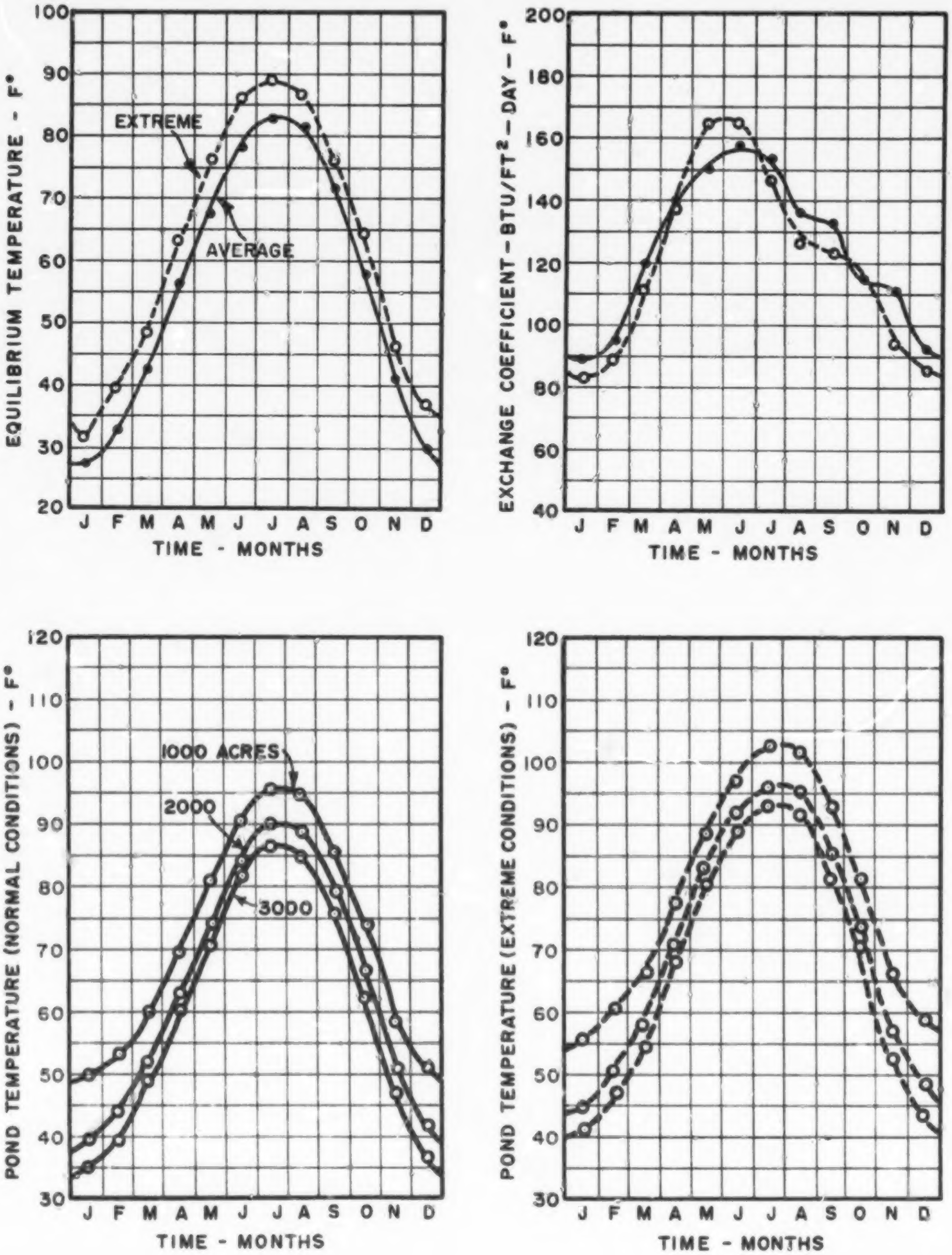

FIGURE 64 - RESULTS FOR SPRINGFIELD, ILLINOIS

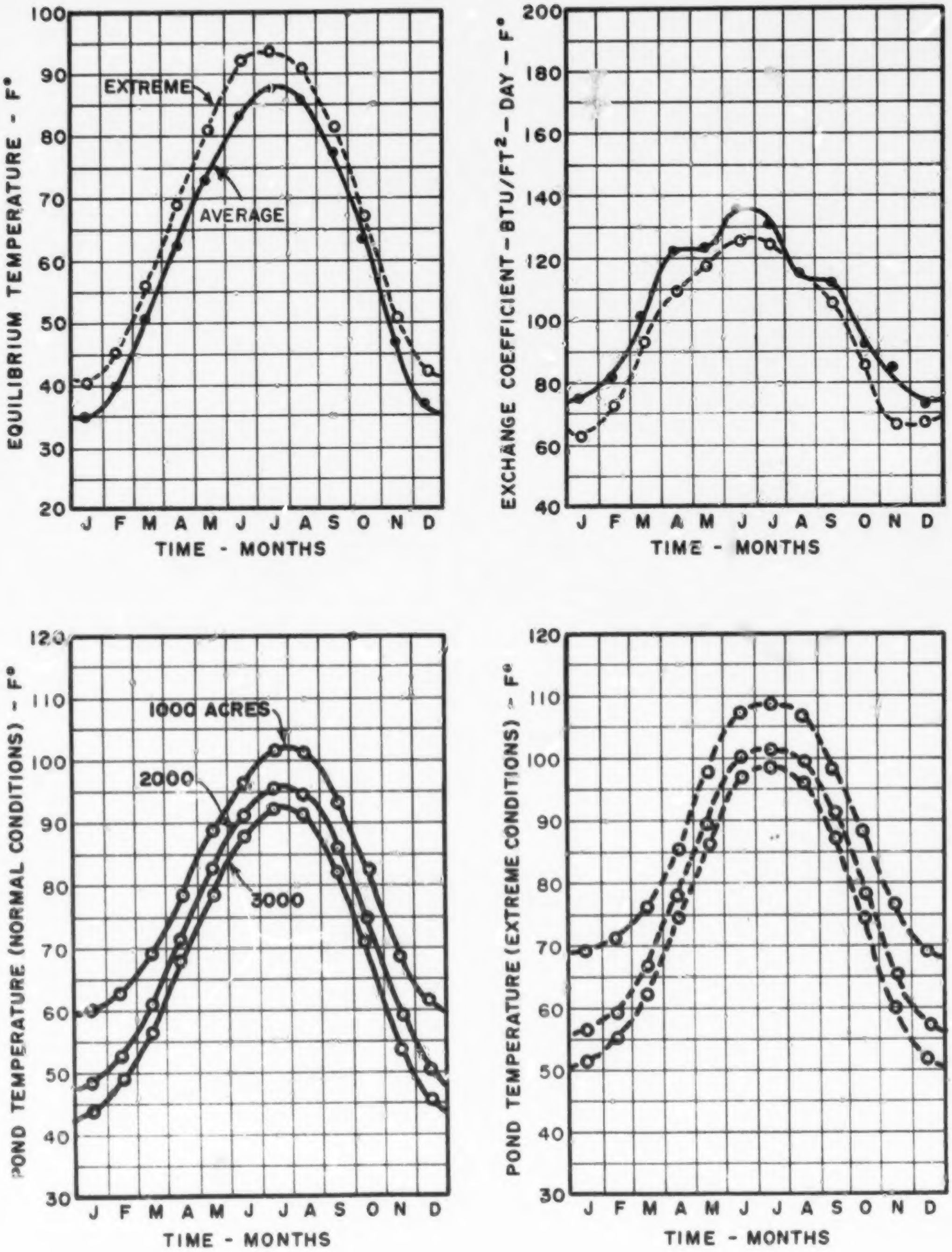

FIGURE 65 - RESULTS FOR EVANSVILLE, INDIANA

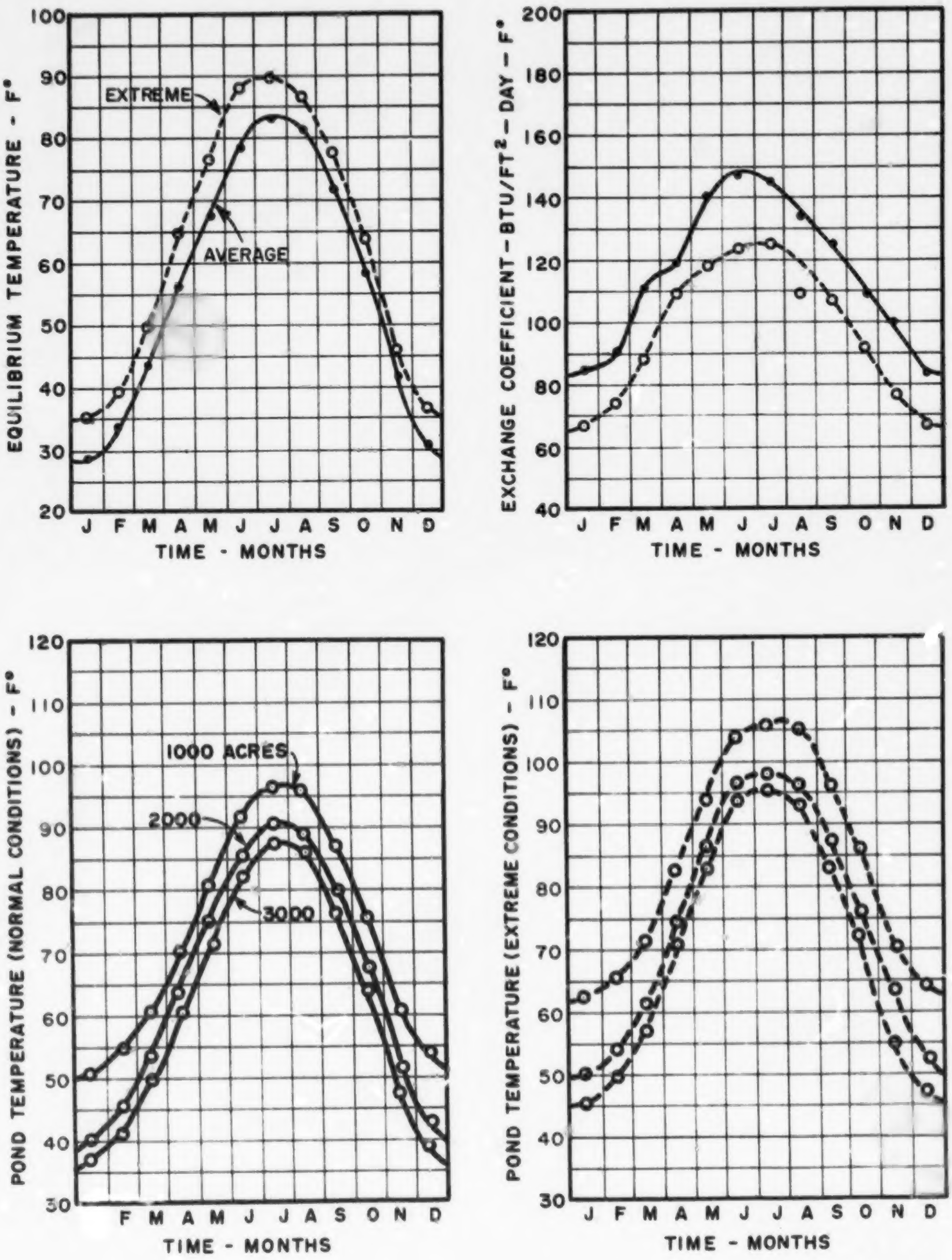

FIGURE 66 - RESULTS FOR INDIANAPOLIS, INDIANA

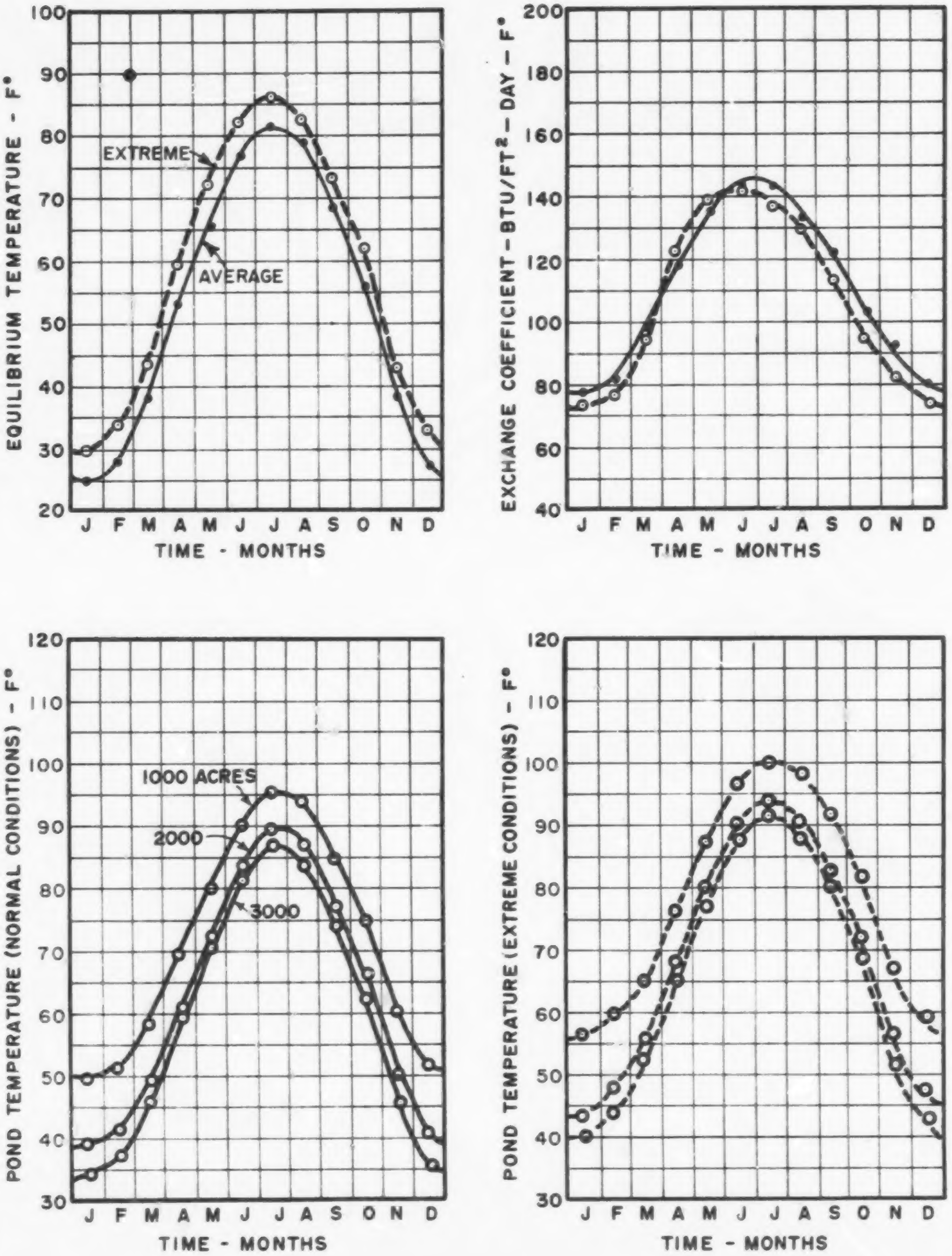

FIGURE 67 - RESULTS FOR SOUTH BEND, INDIANA

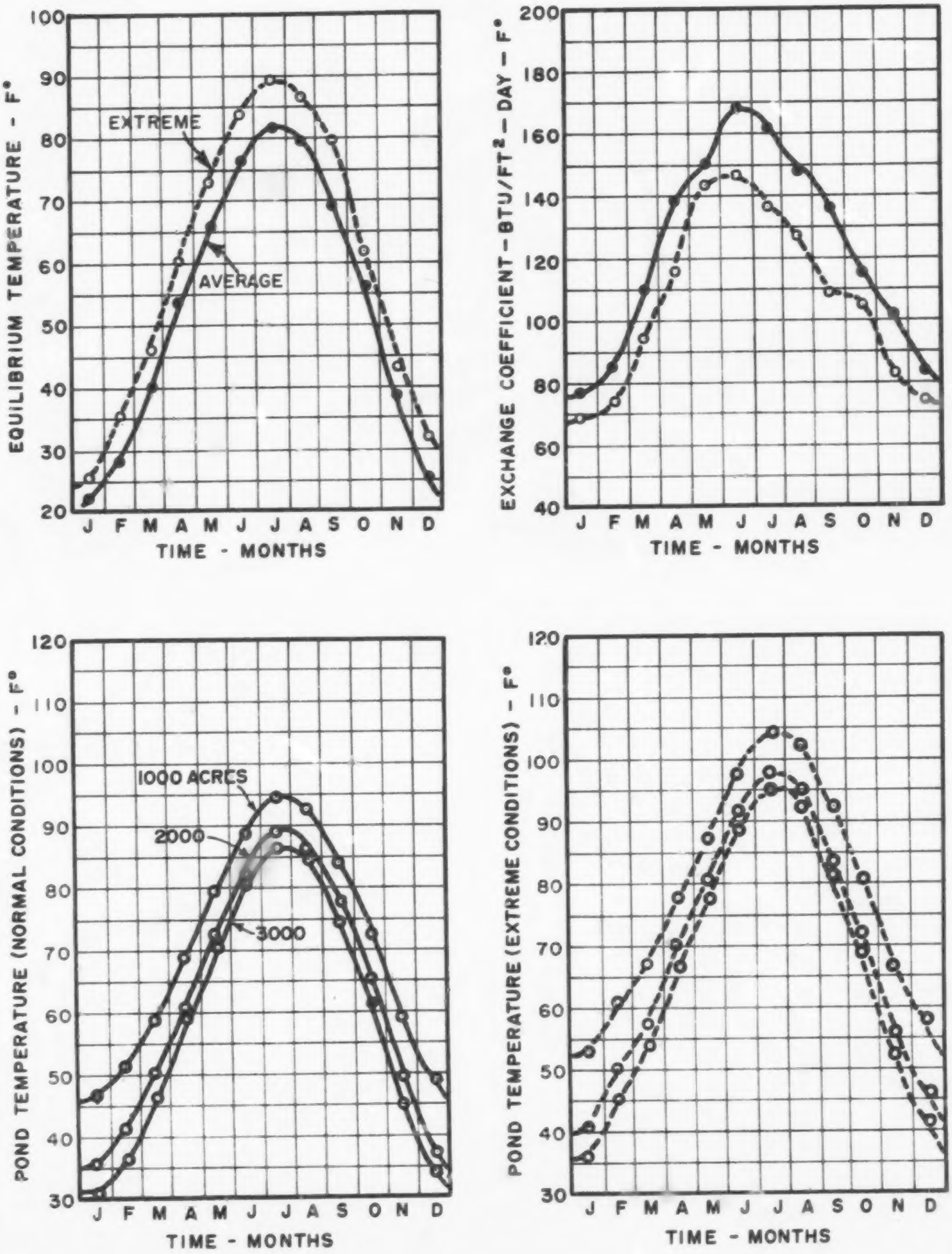

FIGURE 68 - RESULTS FOR DES MOINES, IOWA

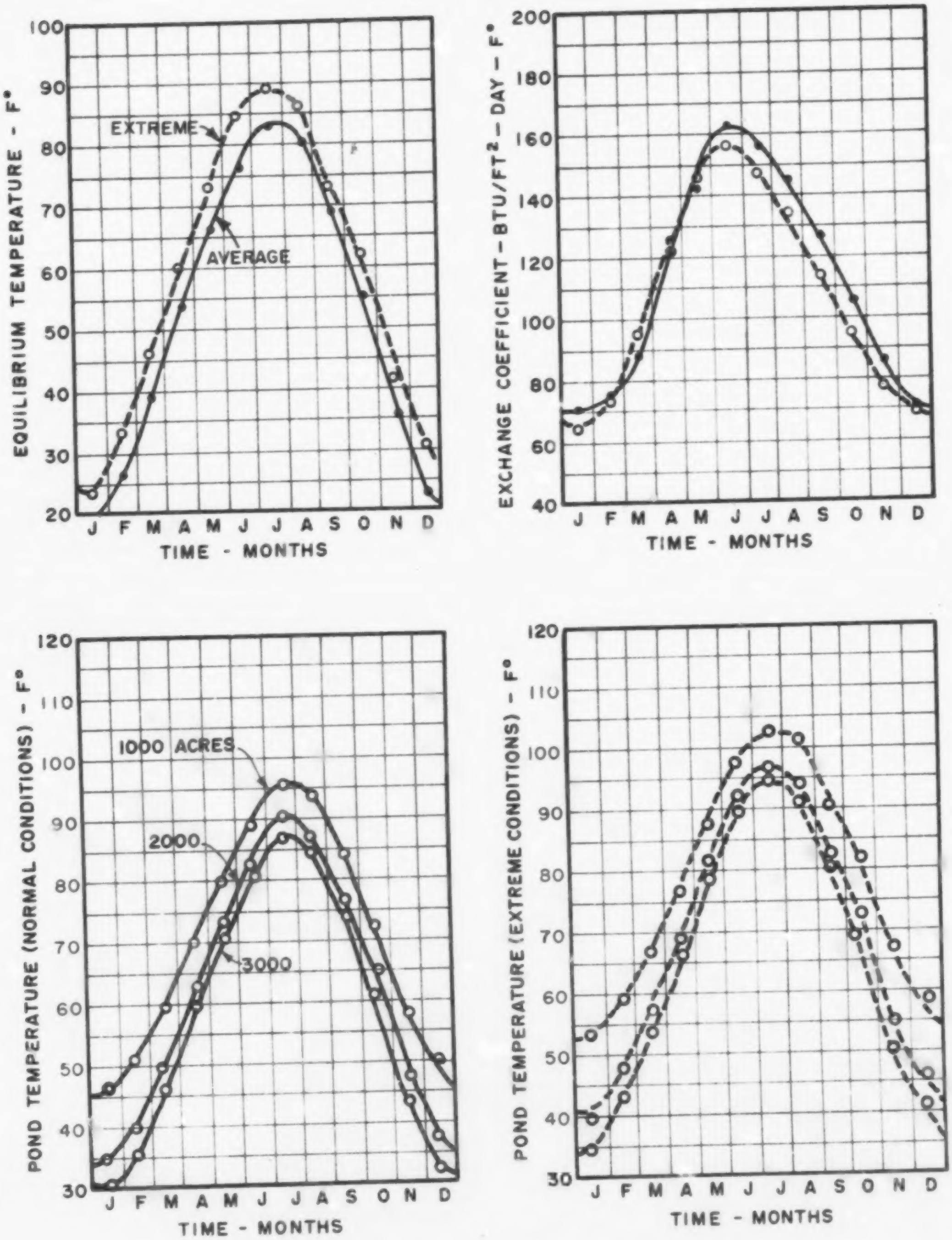

FIGURE 69 - RESULTS FOR SIOUX CITY, IOWA

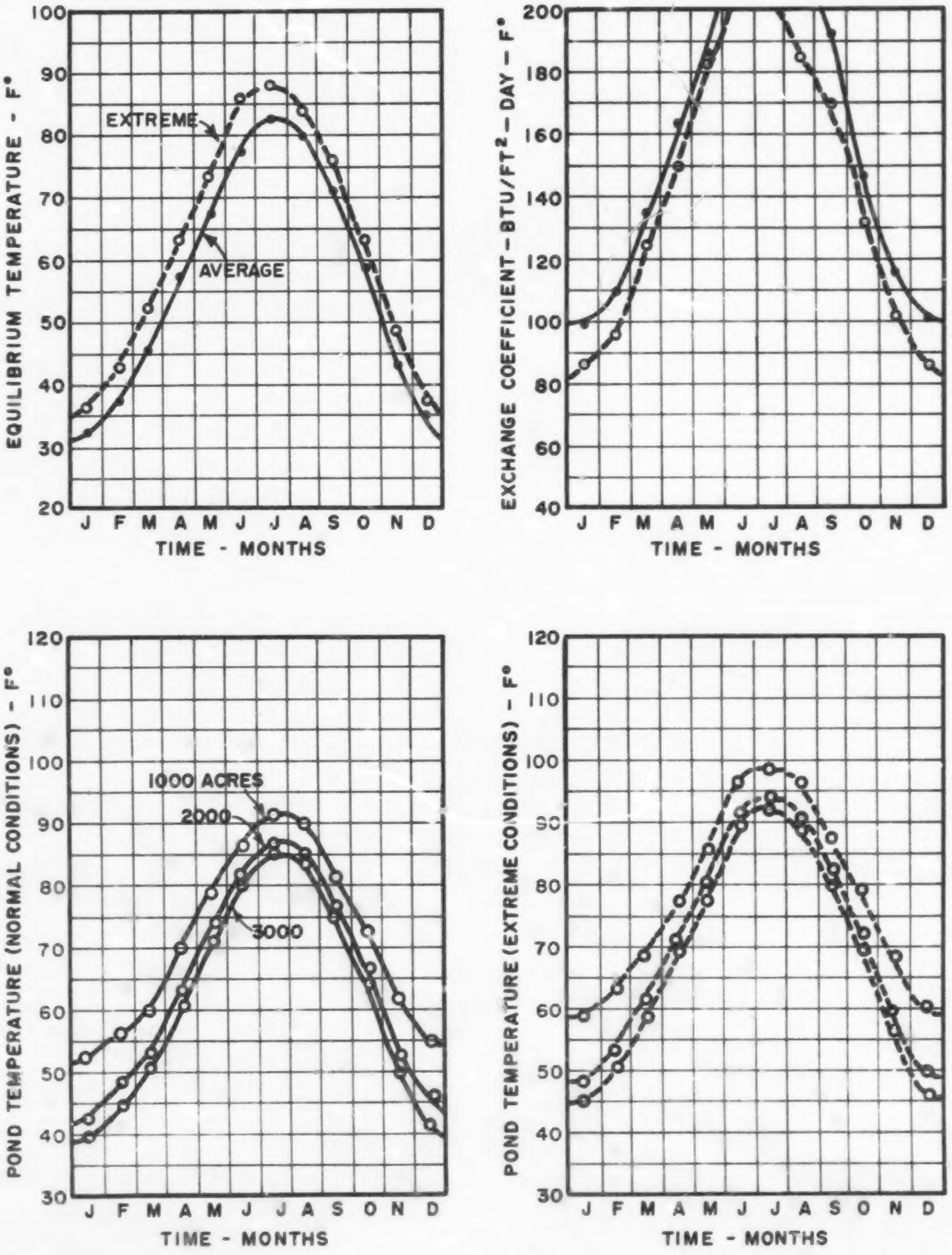

FIGURE 70 - RESULTS FOR DODGE CITY, KANSAS

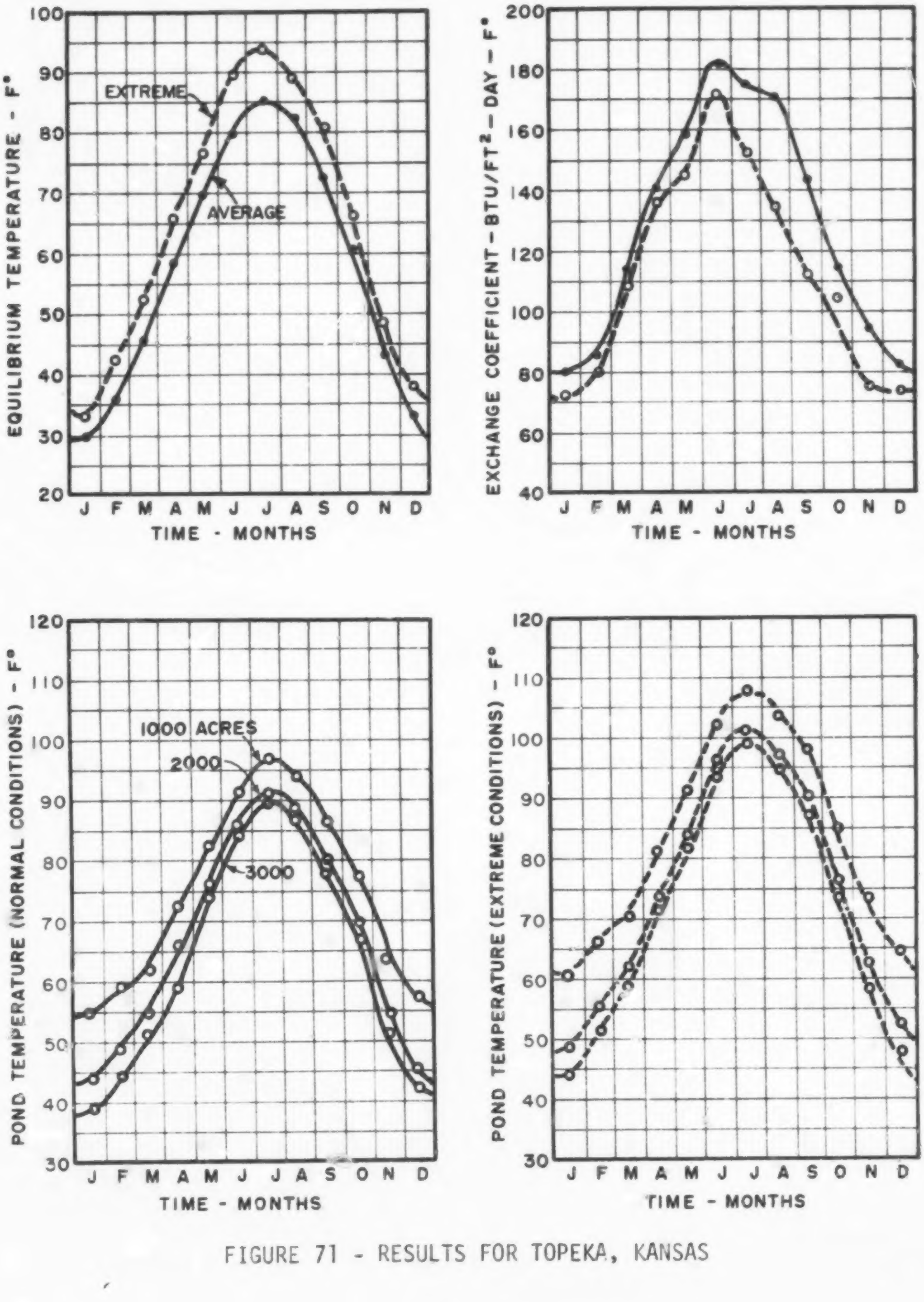

FIGURE 71 - RESULTS FOR TOPEKA, KANSAS

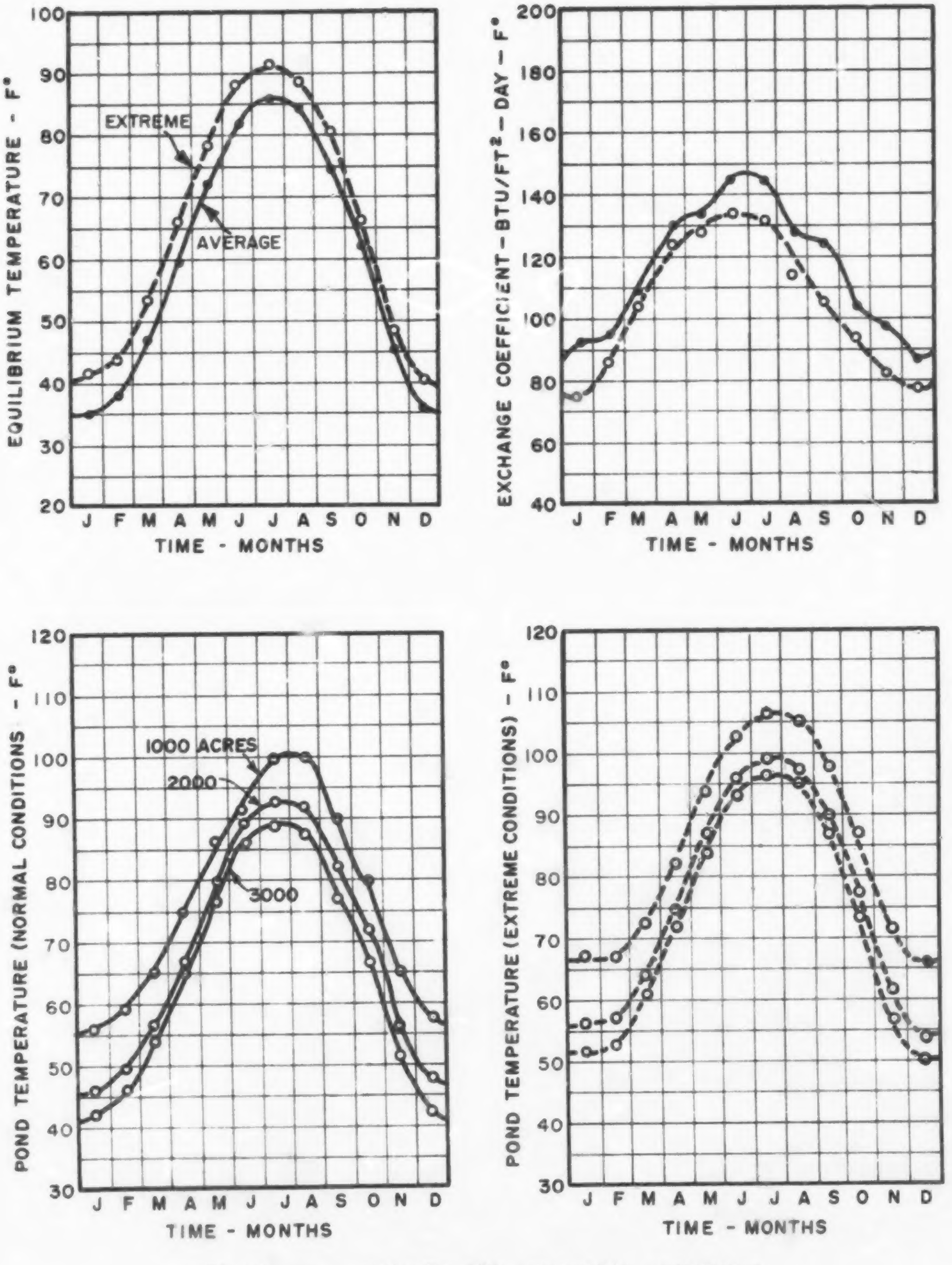

FIGURE 72 - RESULTS FOR LEXINGTON, KENTUCKY

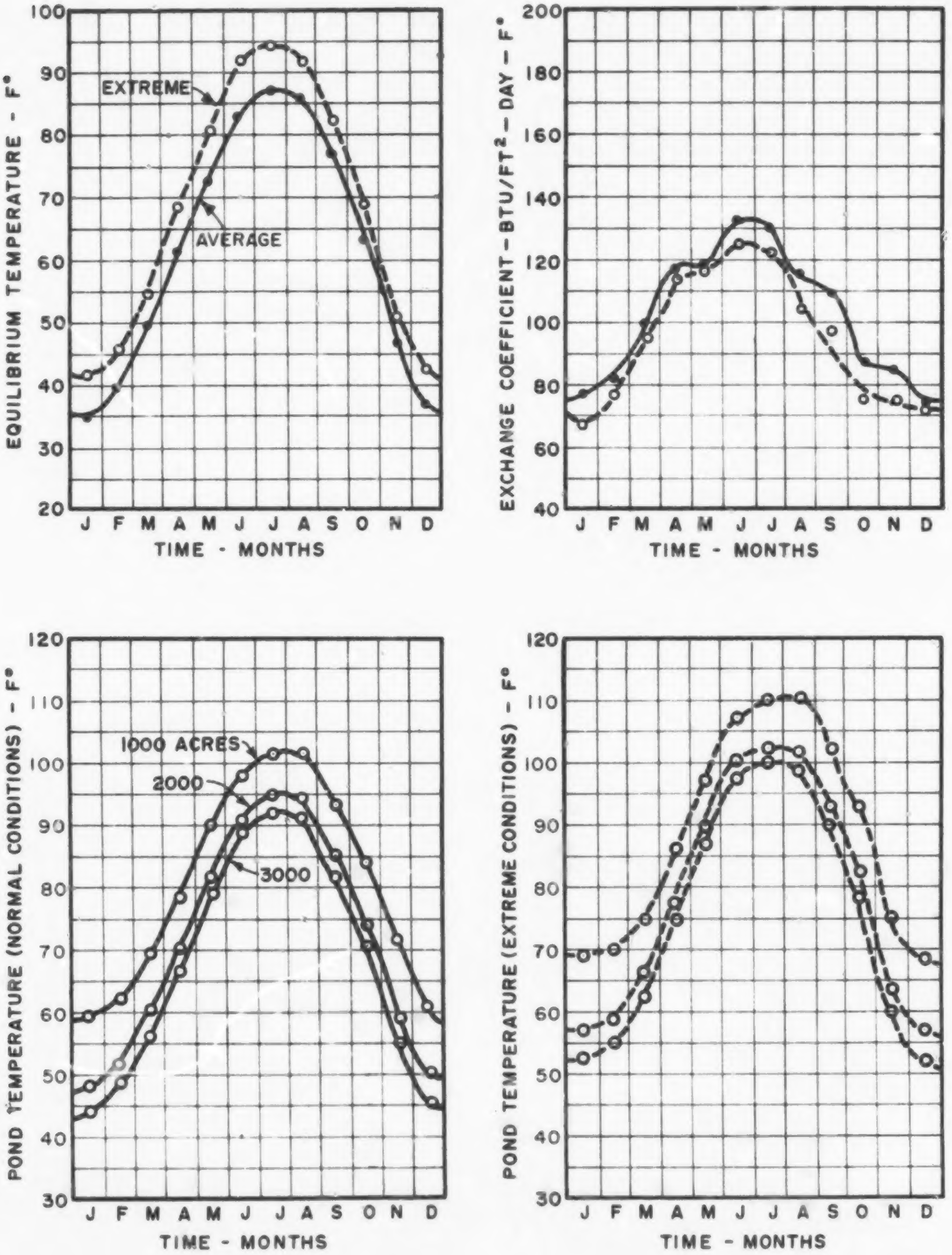

FIGURE 73 - RESULTS FOR LOUISVILLE, KENTUCKY

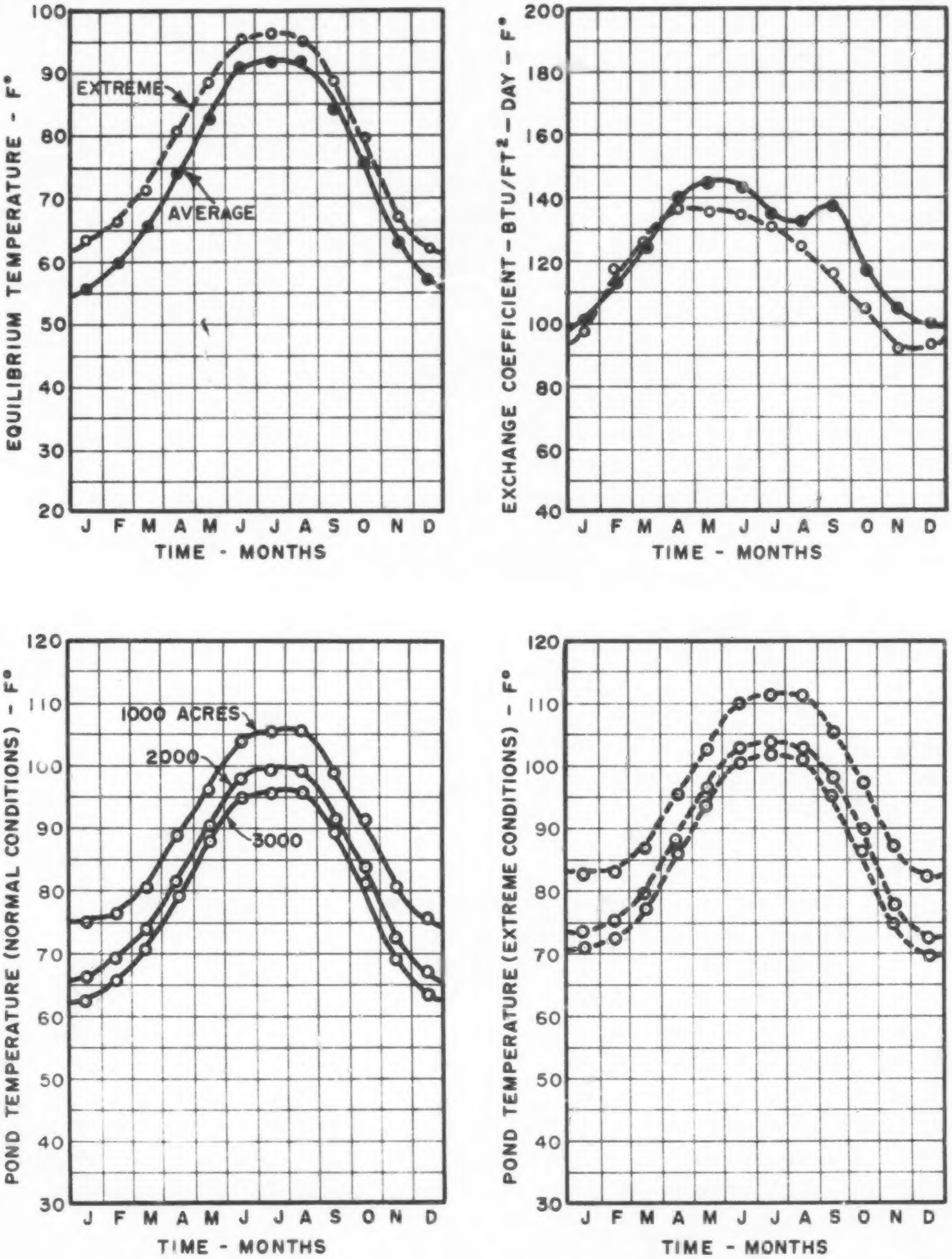

FIGURE 74 - RESULTS FOR NEW ORLEANS, LOUISIANA

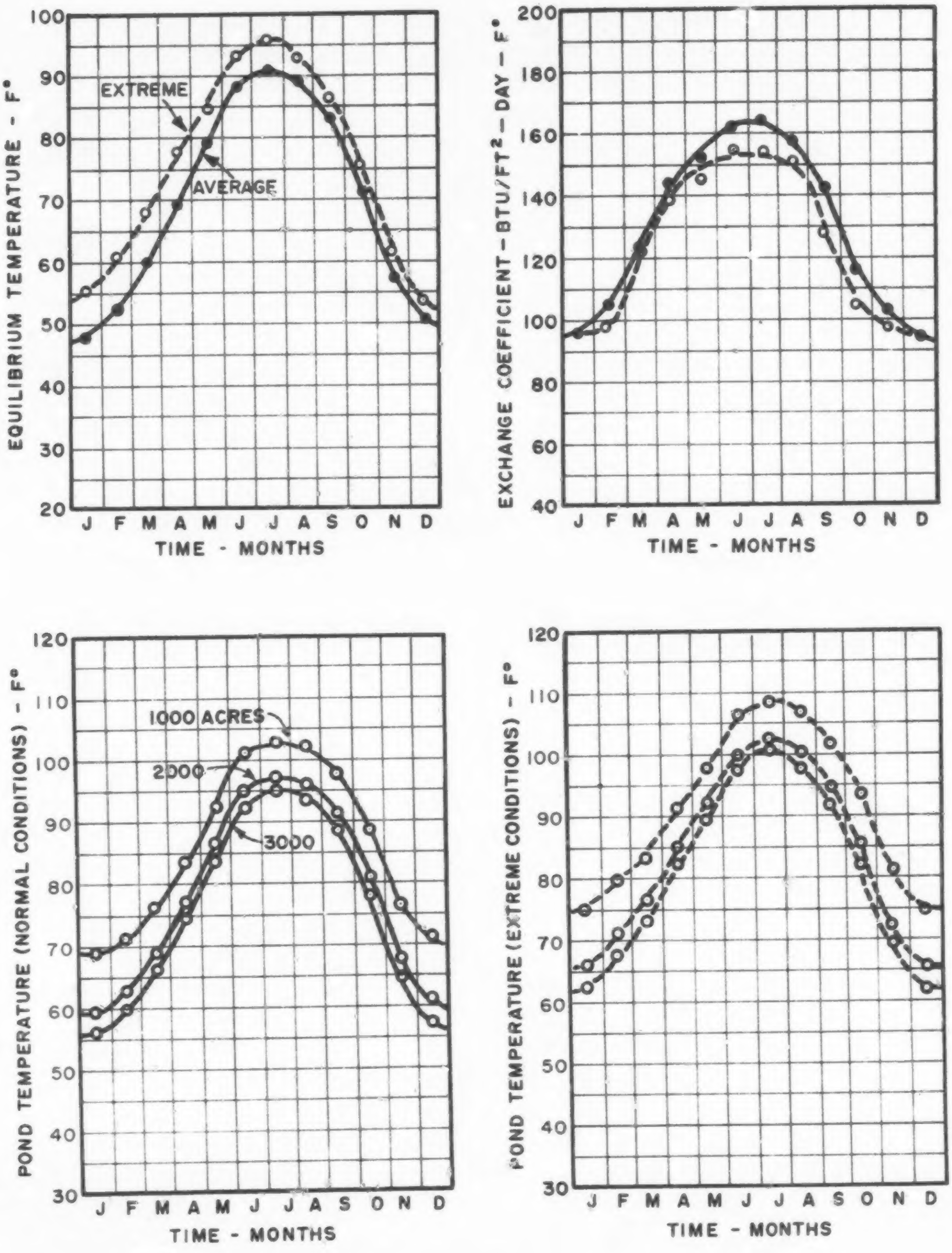

FIGURE 75 - RESULTS FOR SHREVEPORT, LOUISIANA

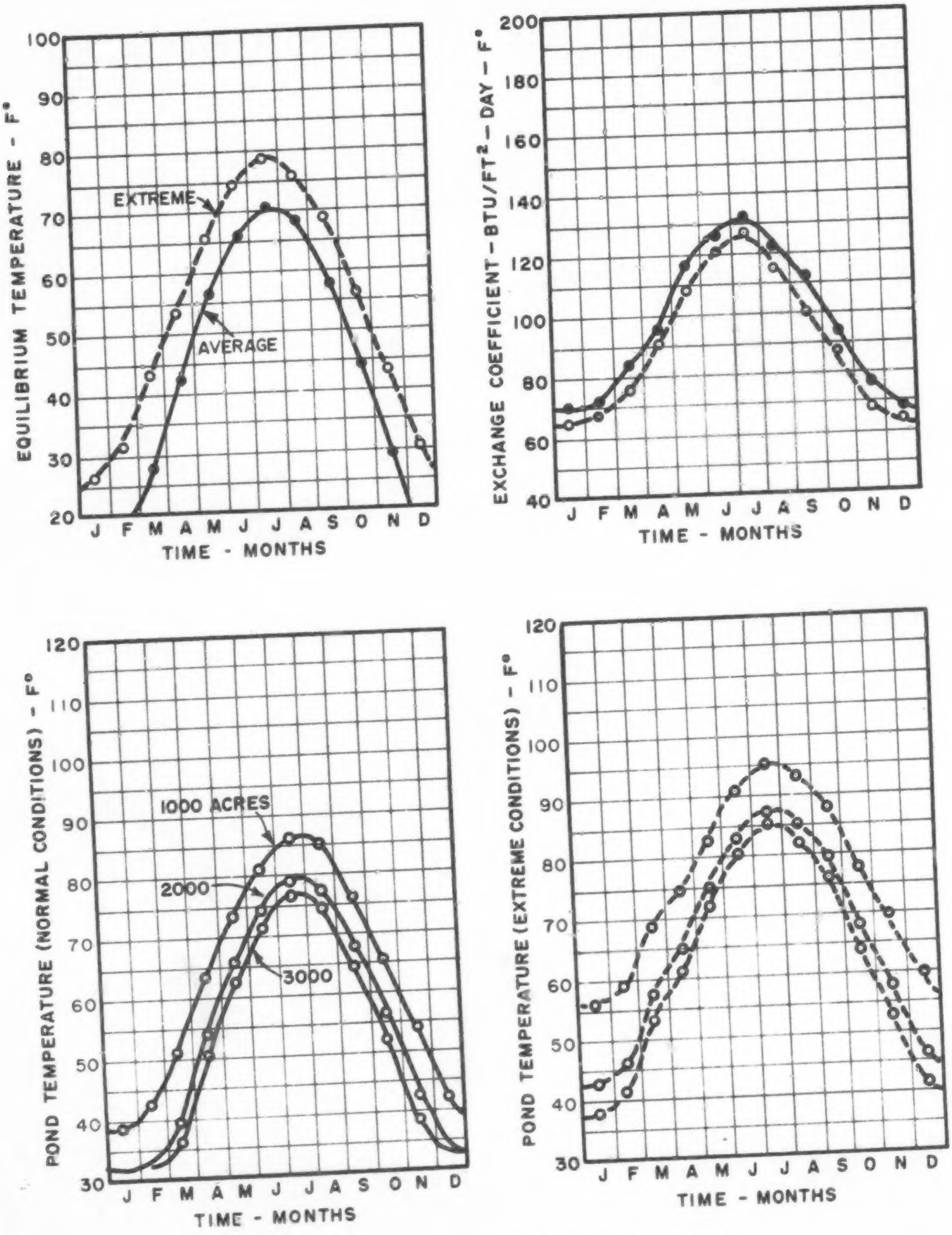

FIGURE 76 - RESULTS FOR CARIBOU, MAINE

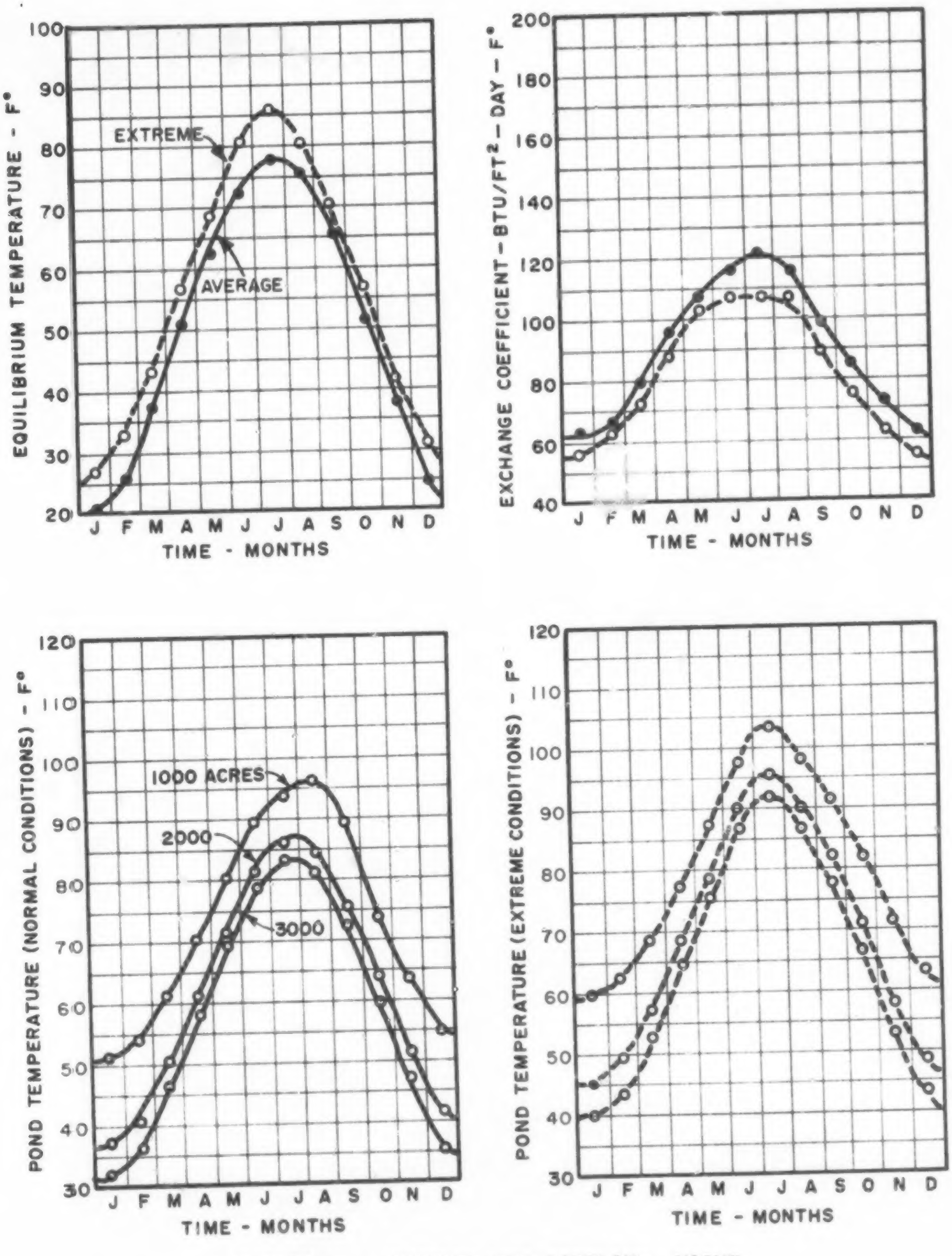

FIGURE 77 - RESULTS FOR PORTLAND, MAINE

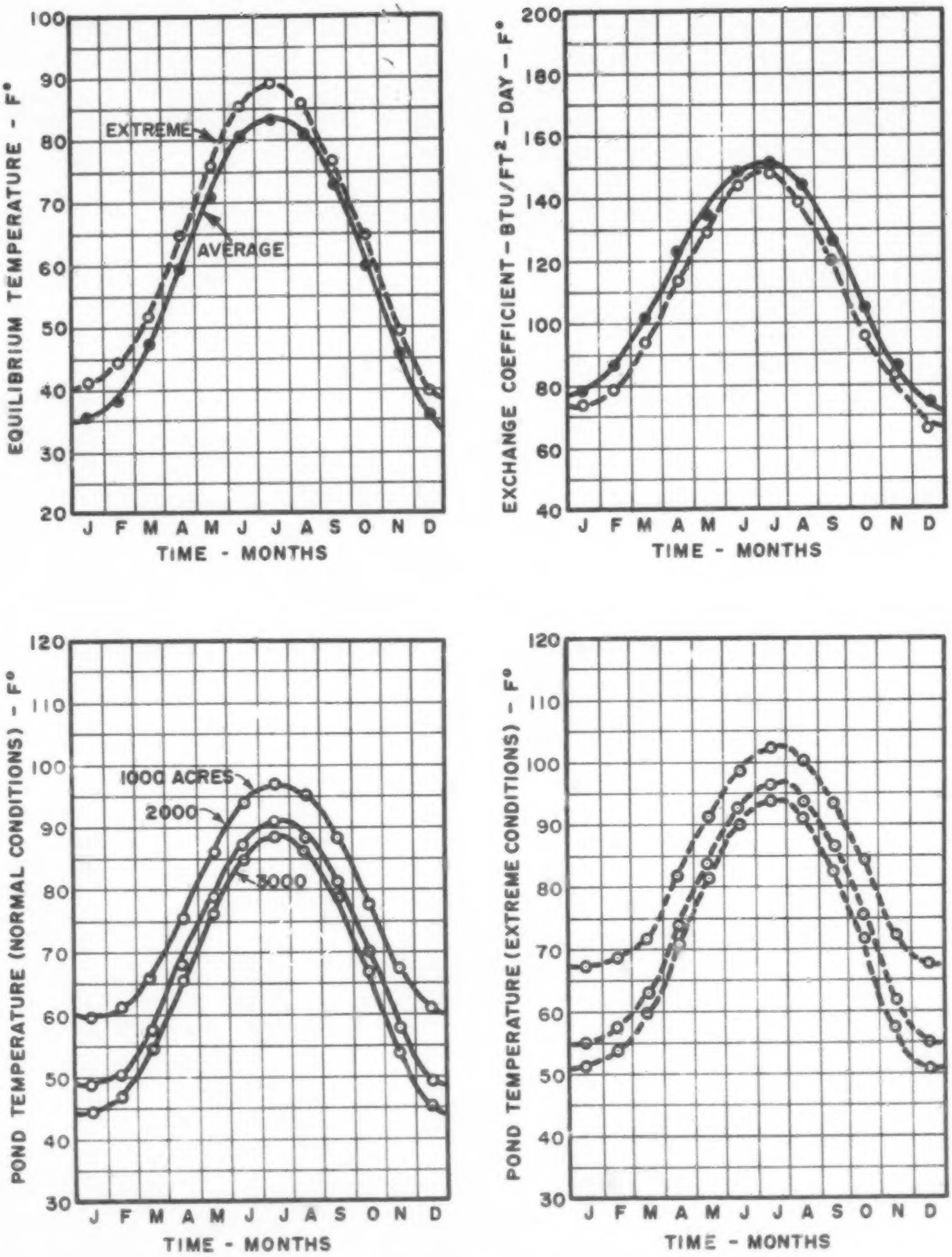

FIGURE 78 - RESULTS FOR BALTIMORE, MARYLAND

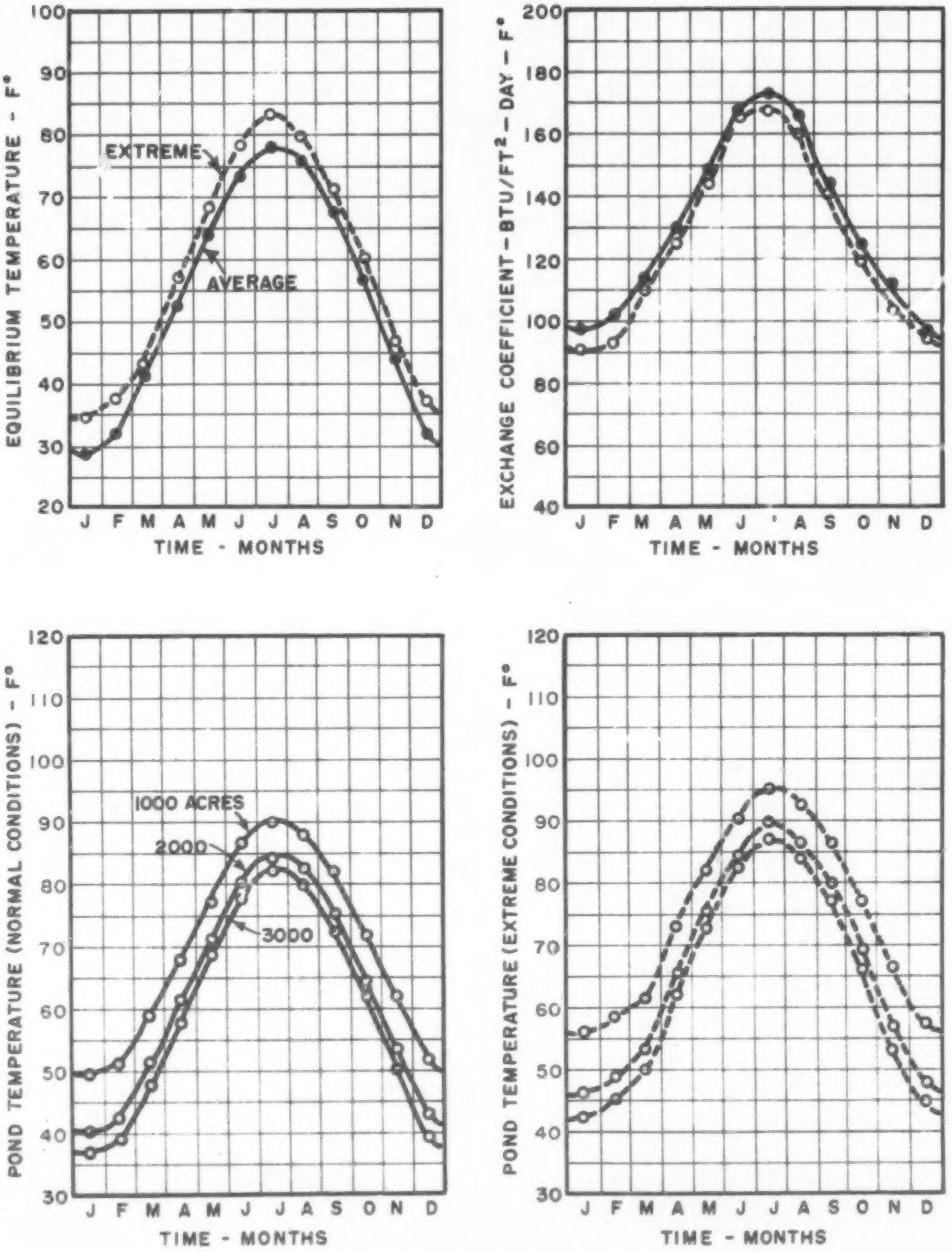

FIGURE 79 - RESULTS FOR BOSTON, MASSACHUSETTS

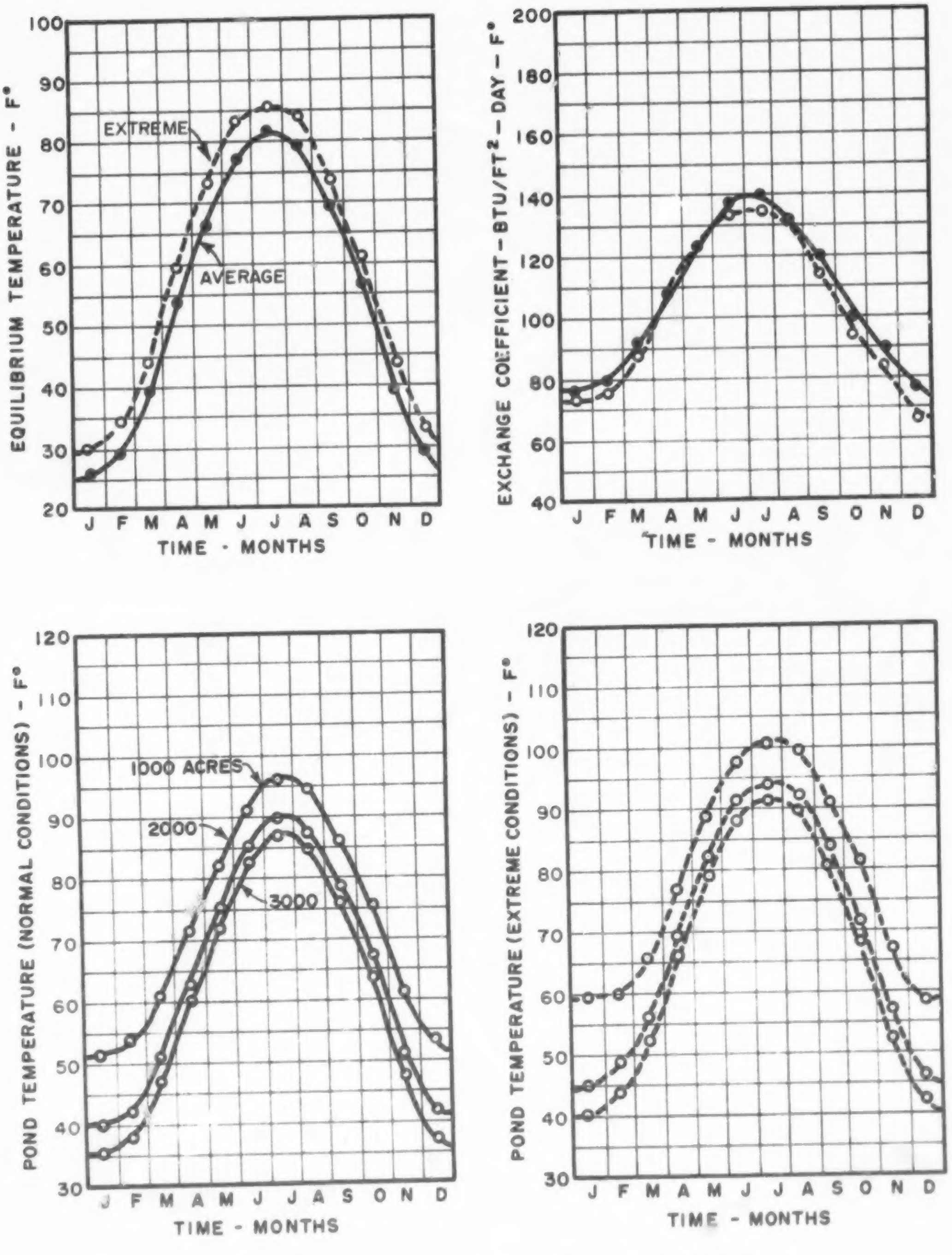

FIGURE 80 - RESULTS FOR DETROIT, MICHIGAN

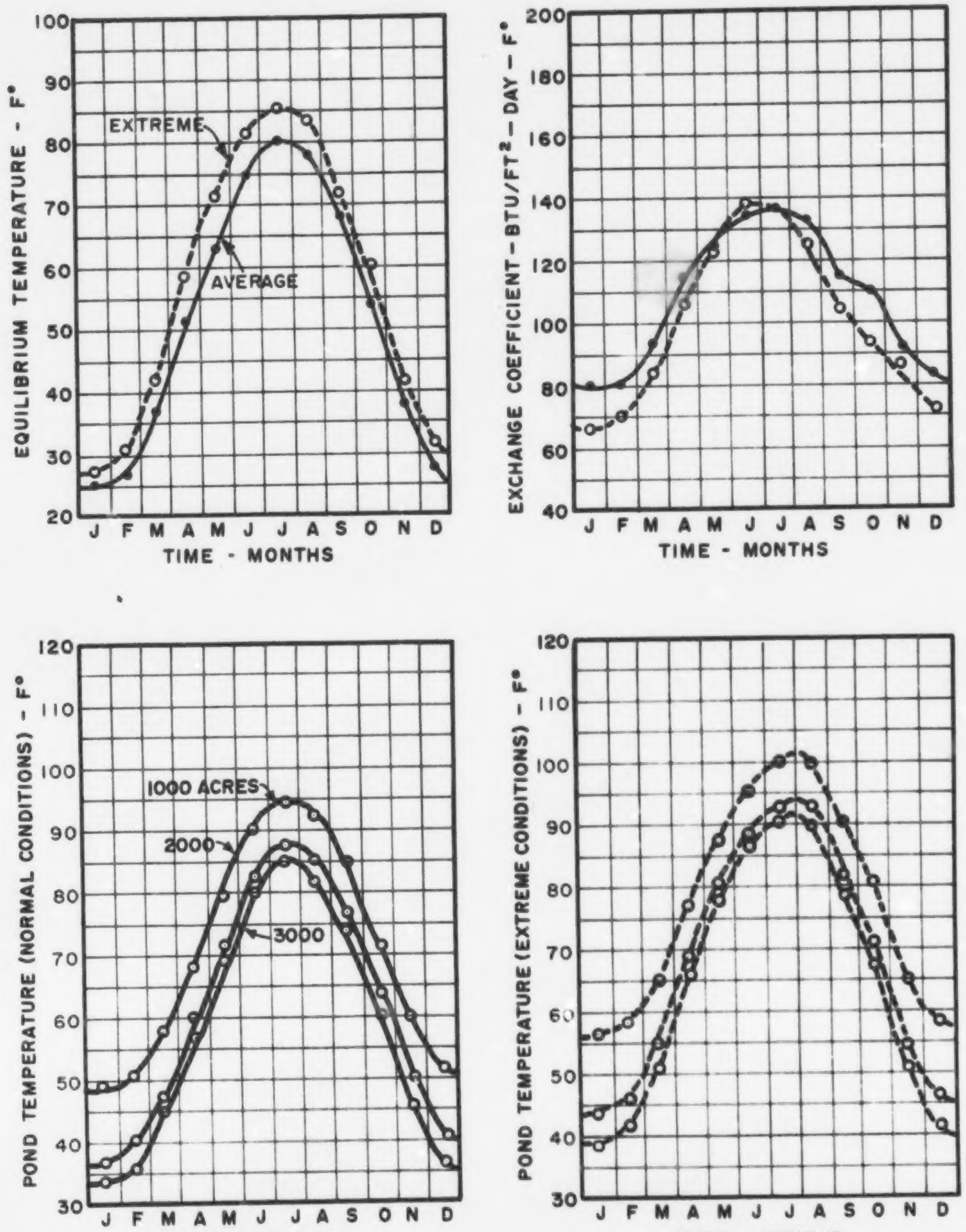

FIGURE 81 - RESULTS FOR MUSKEGON, MICHIGAN

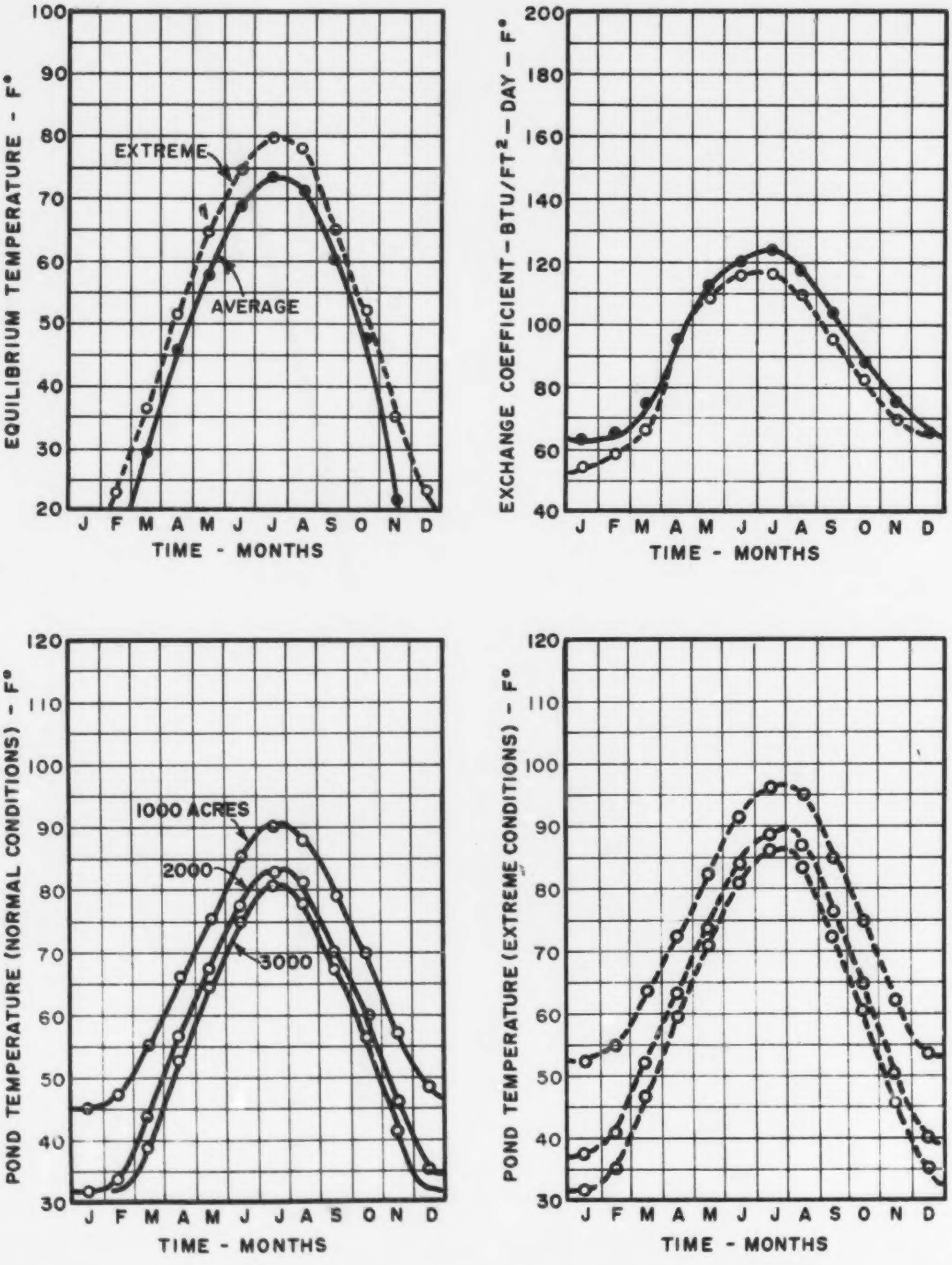

FIGURE 82 - RESULTS FOR SAULT STE. MARIE, MICHIGAN

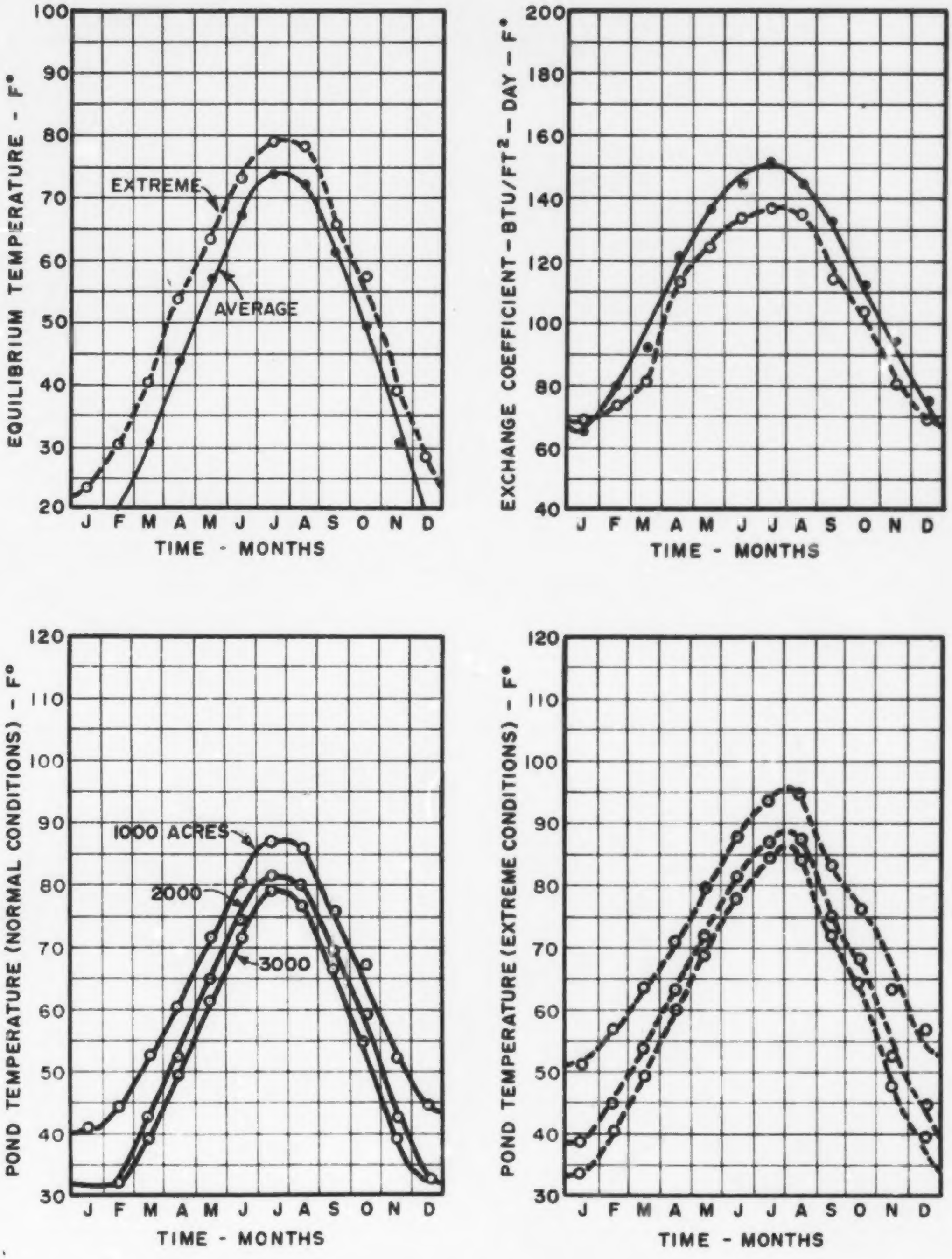

FIGURE 83 - RESULTS FOR DULUTH, MINNESOTA

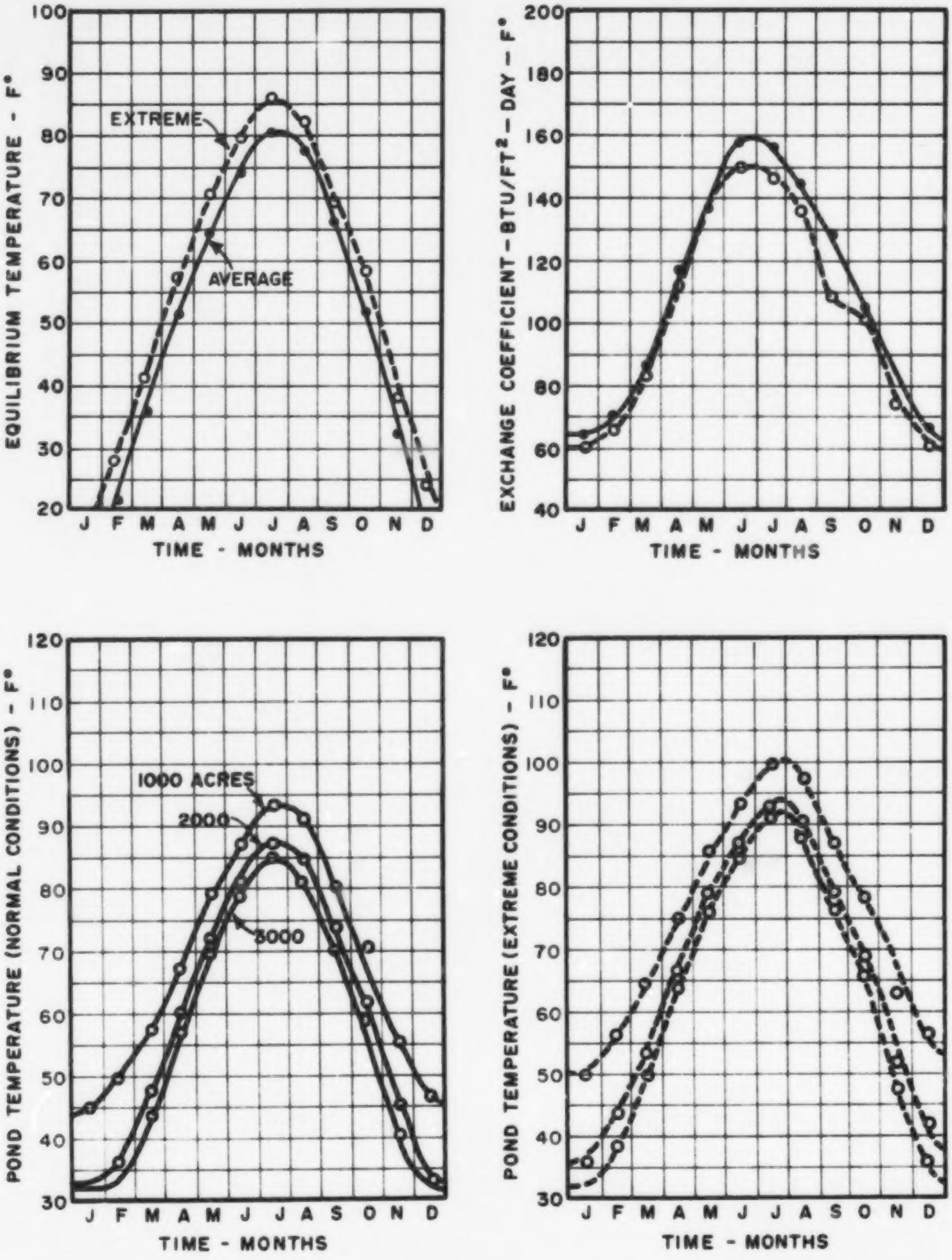

FIGURE 84 - RESULTS FOR MINNEAPOLIS-ST. PAUL, MINNESOTA

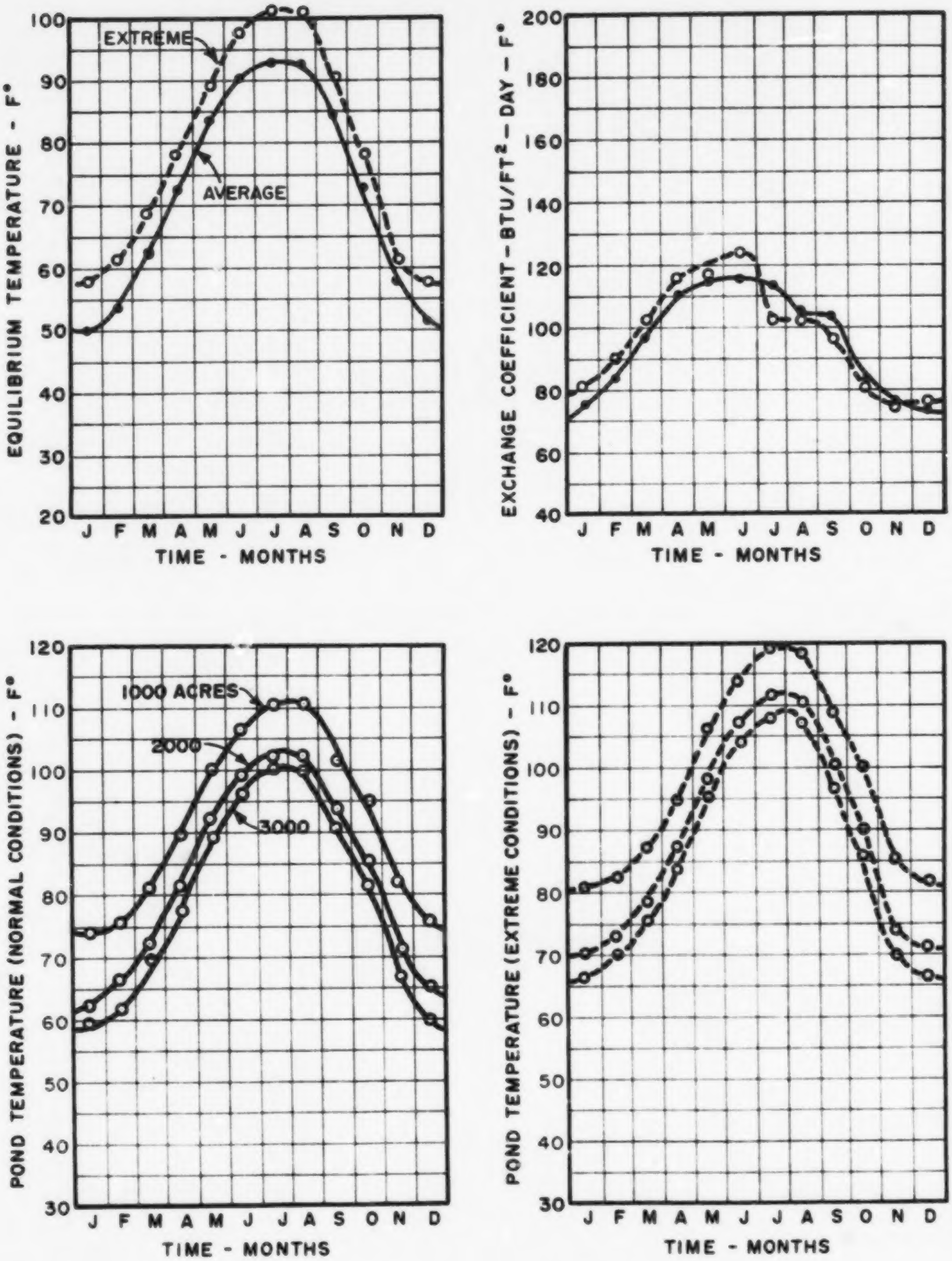

FIGURE 85 - RESULTS FOR JACKSON, MISSISSIPPI

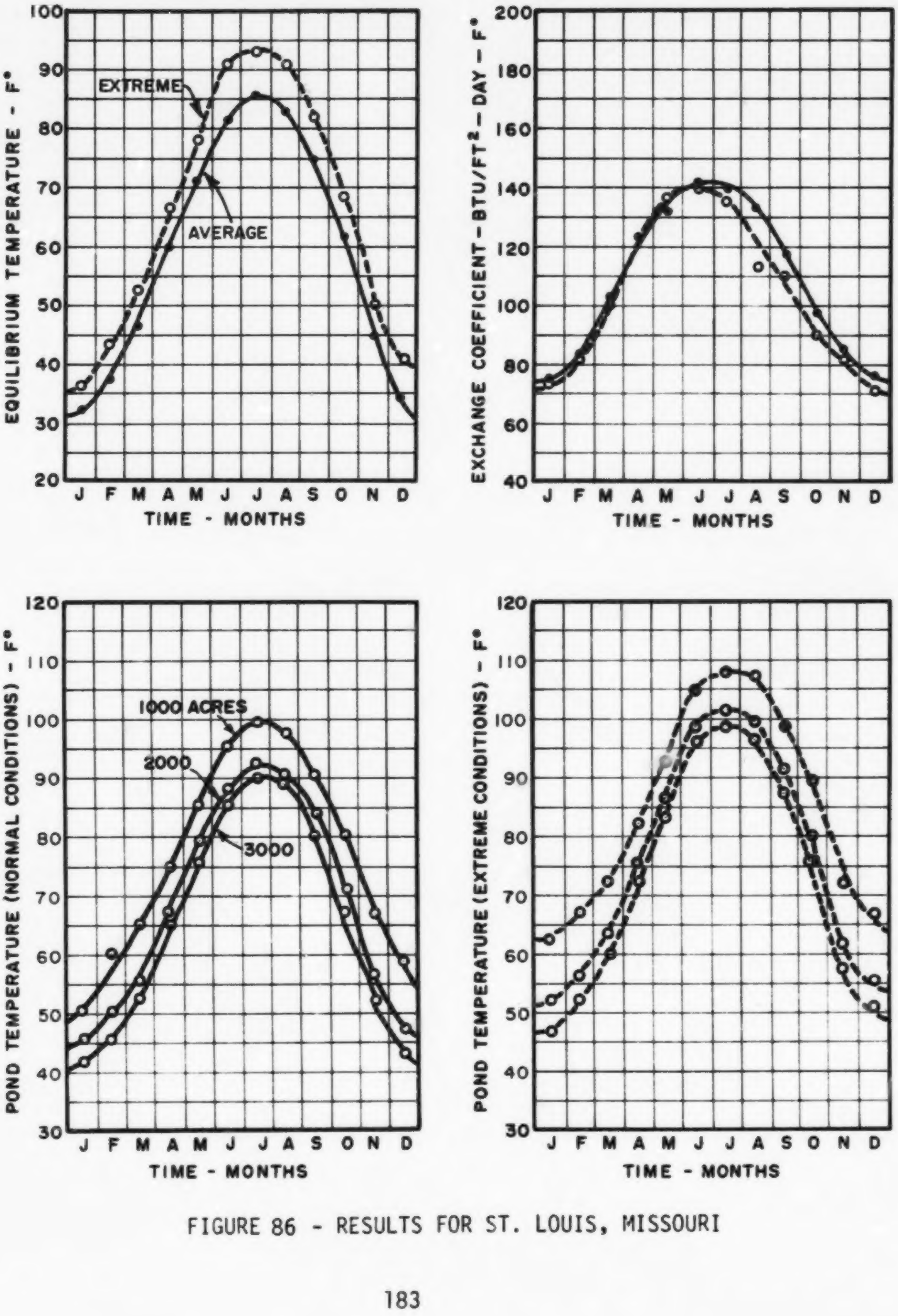

FIGURE 86 - RESULTS FOR ST. LOUIS, MISSOURI

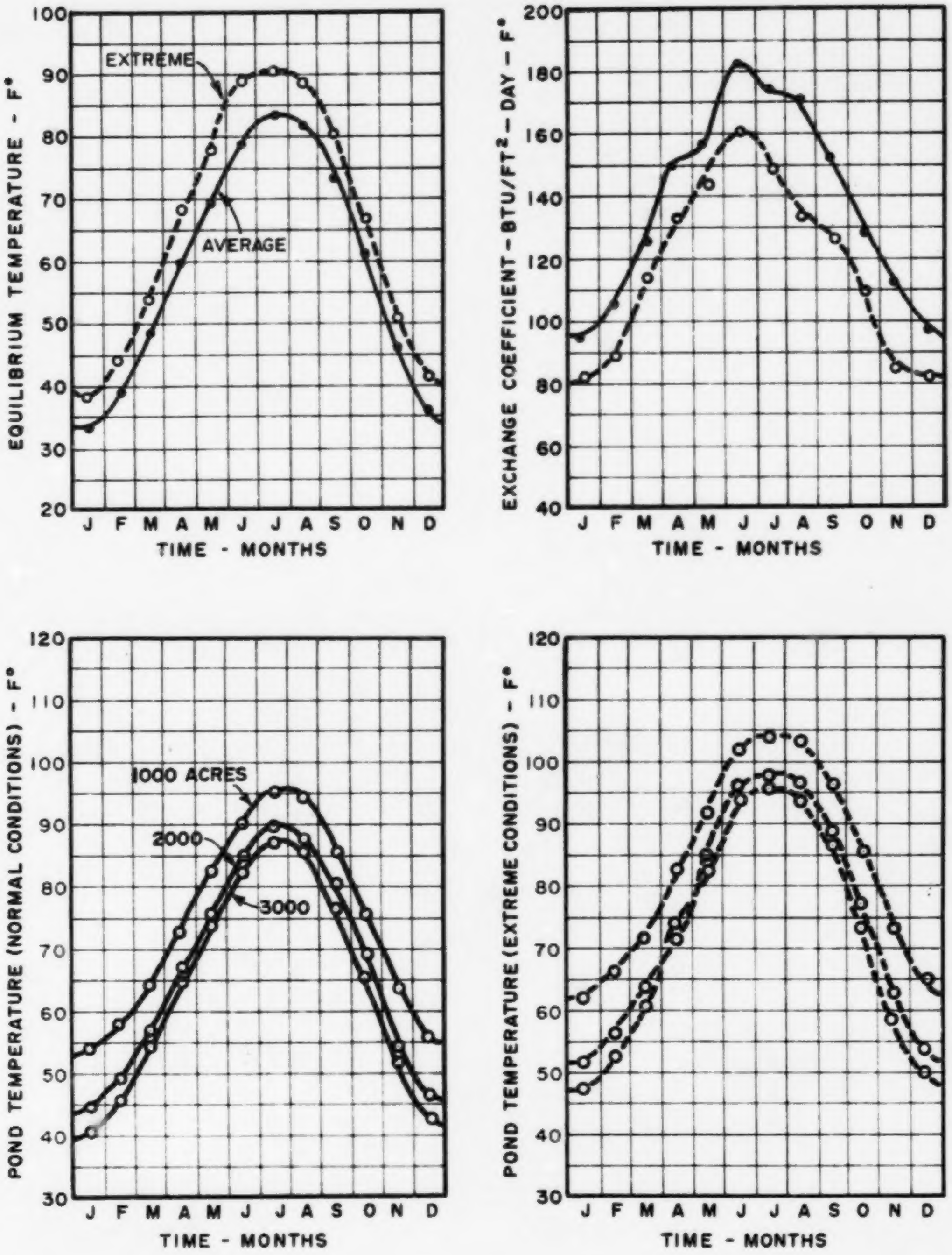

FIGURE 87 - RESULTS FOR SPRINGFIELD, MISSOURI

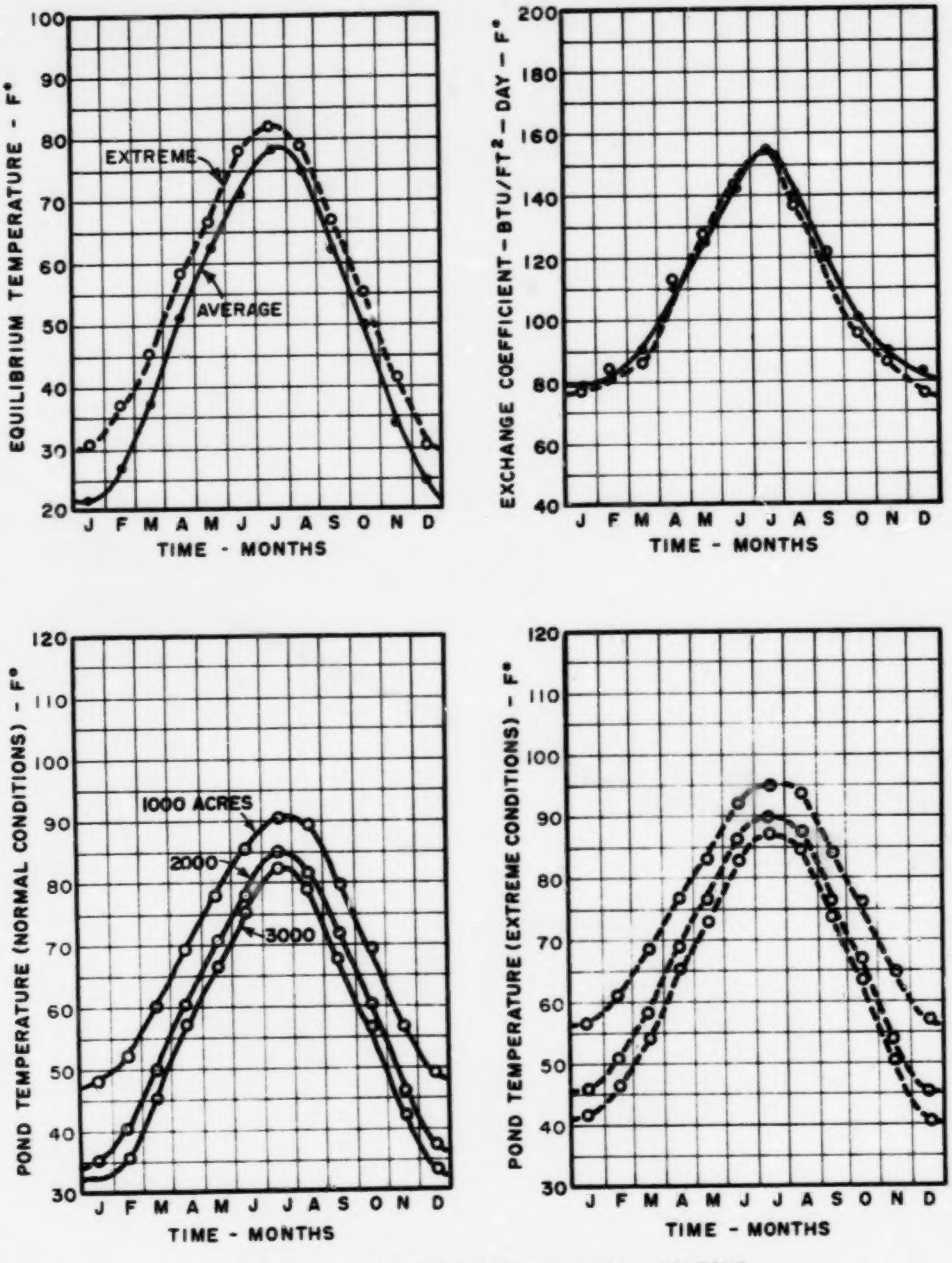

FIGURE 88 - RESULTS FOR BILLINGS, MONTANA

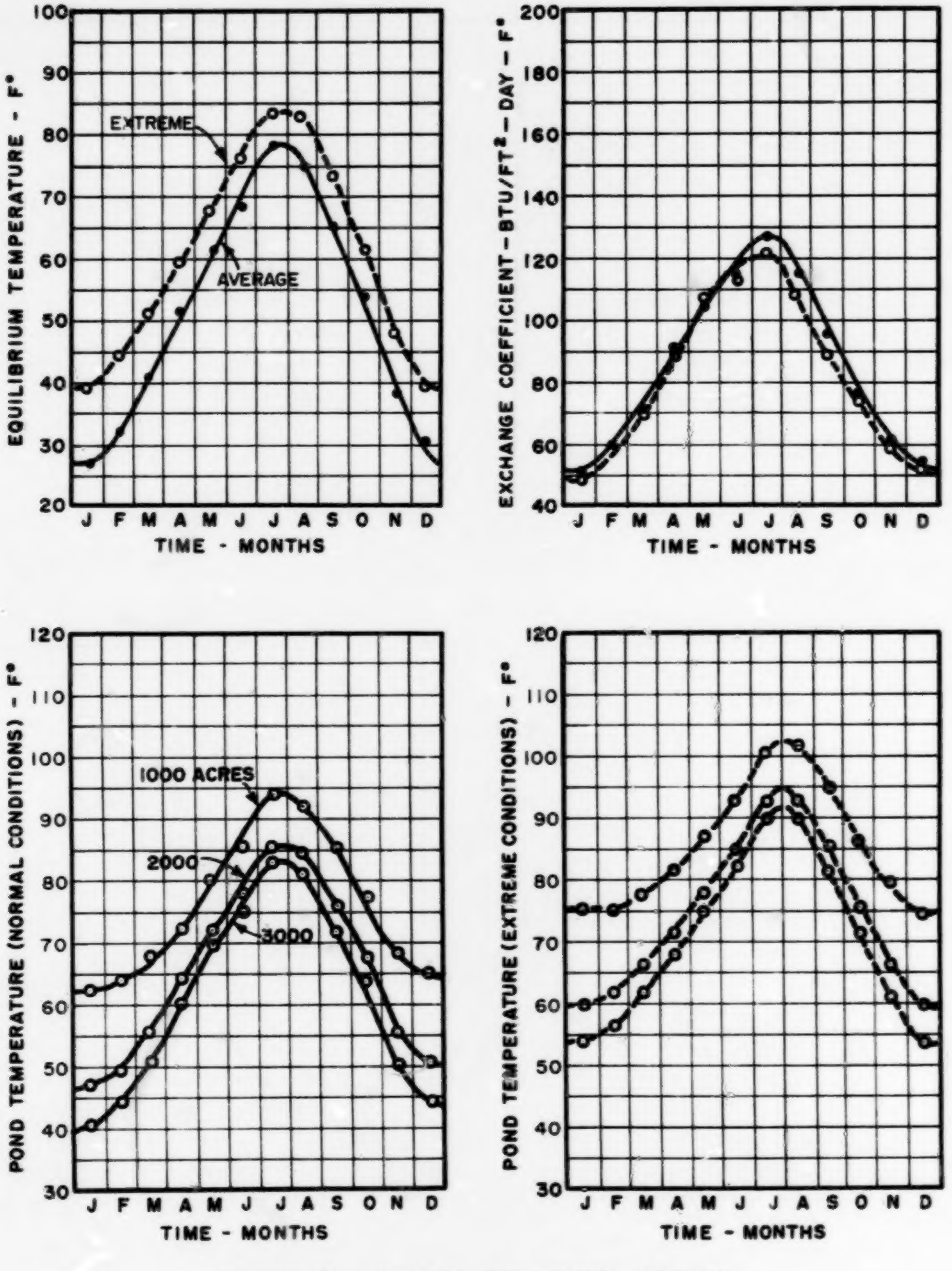

FIGURE 89 - RESULTS FOR HELENA, MONTANA

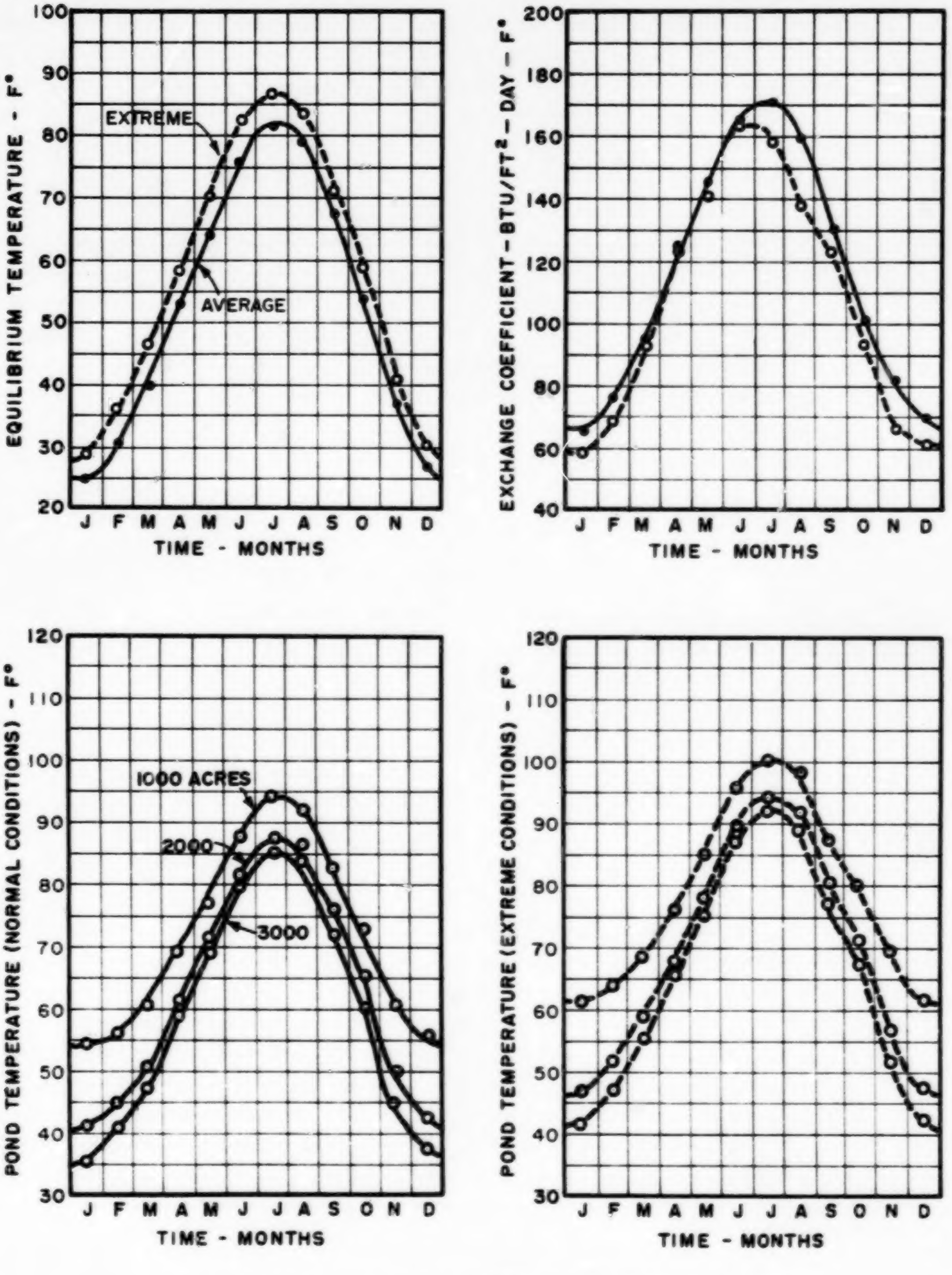

FIGURE 90 - RESULTS FOR NORTH PLATTE, NEBRASKA

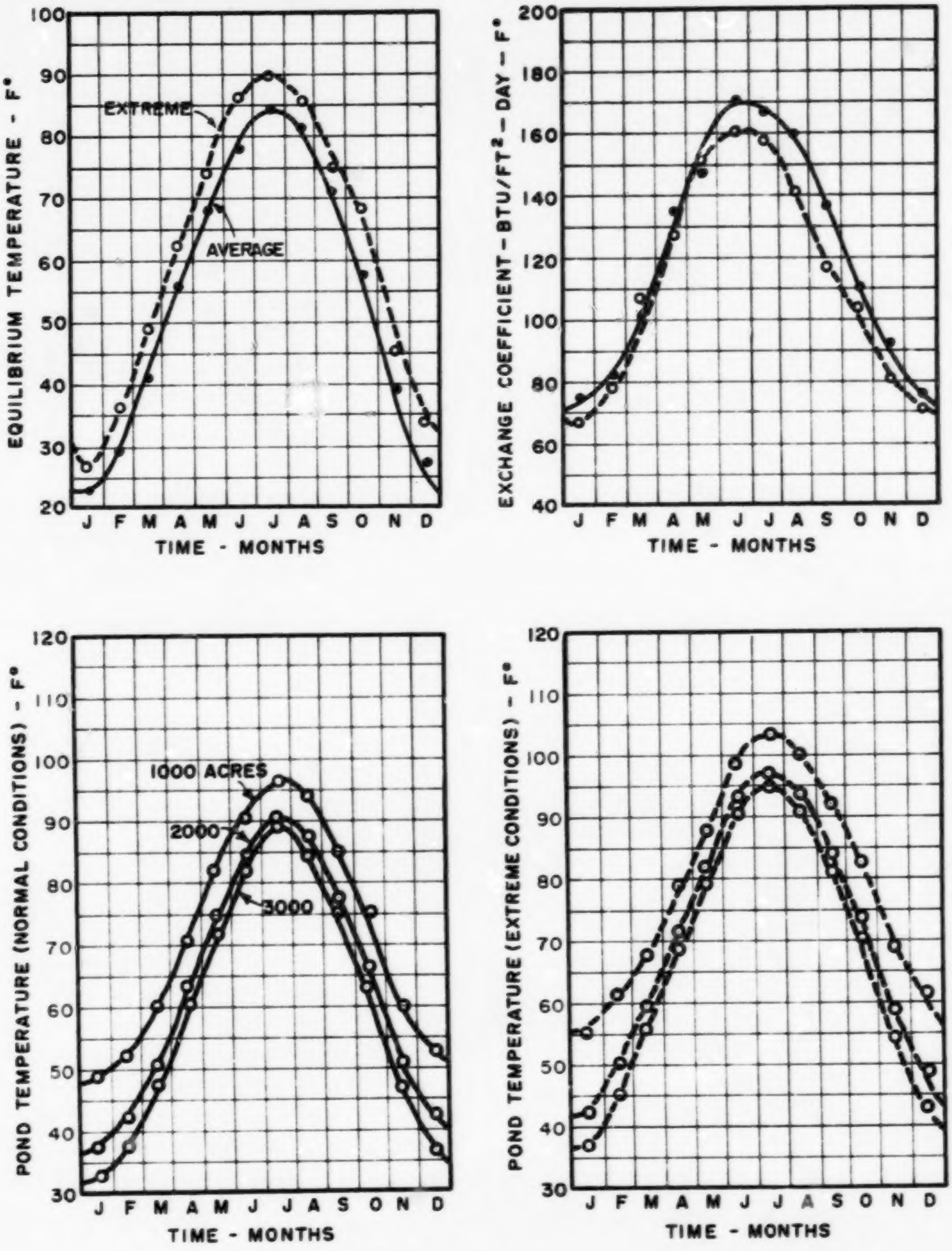

FIGURE 91 - RESULTS FOR OMAHA, NEBRASKA

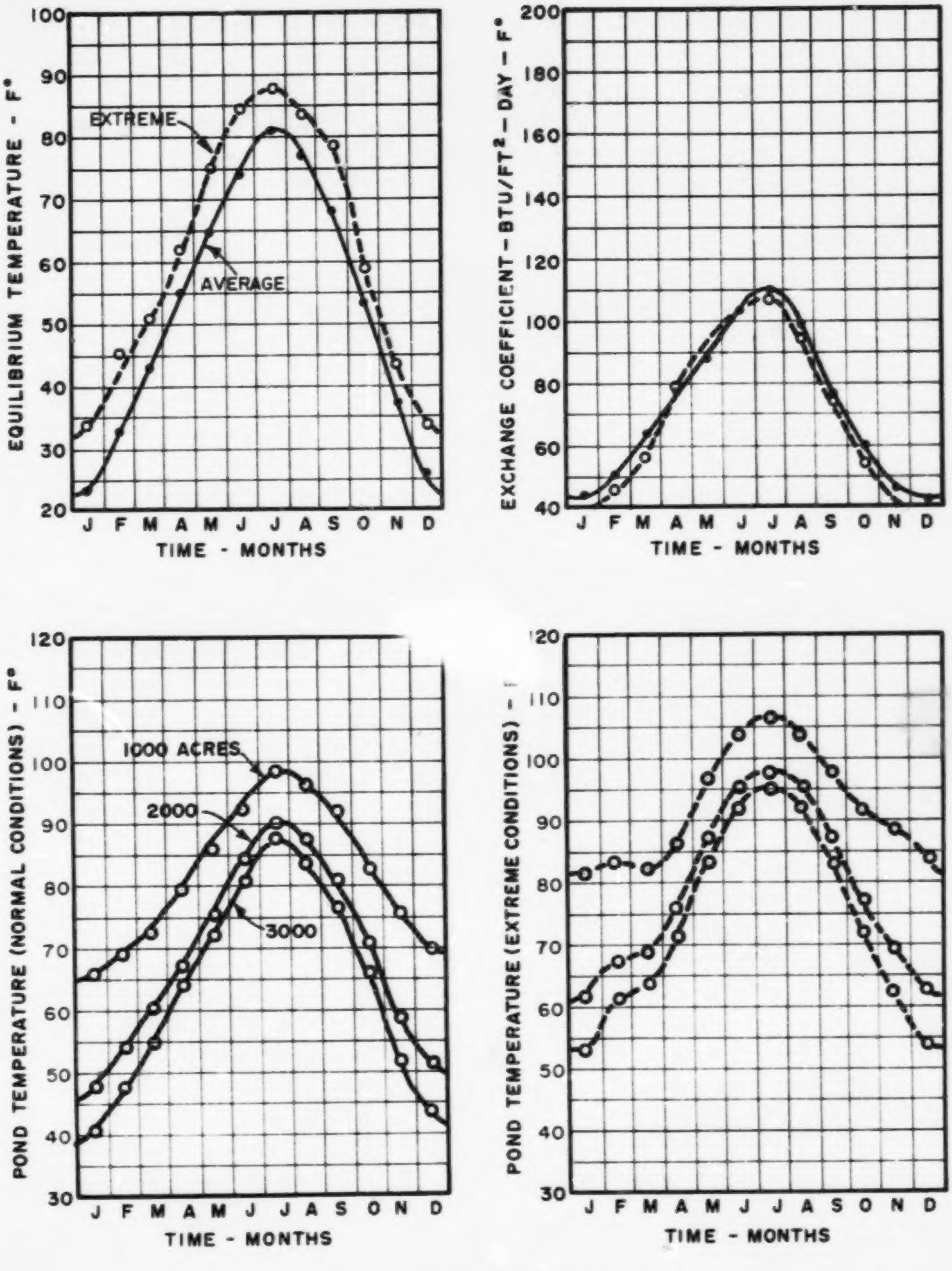

FIGURE 92 - RESULTS FOR ELKO, NEVADA

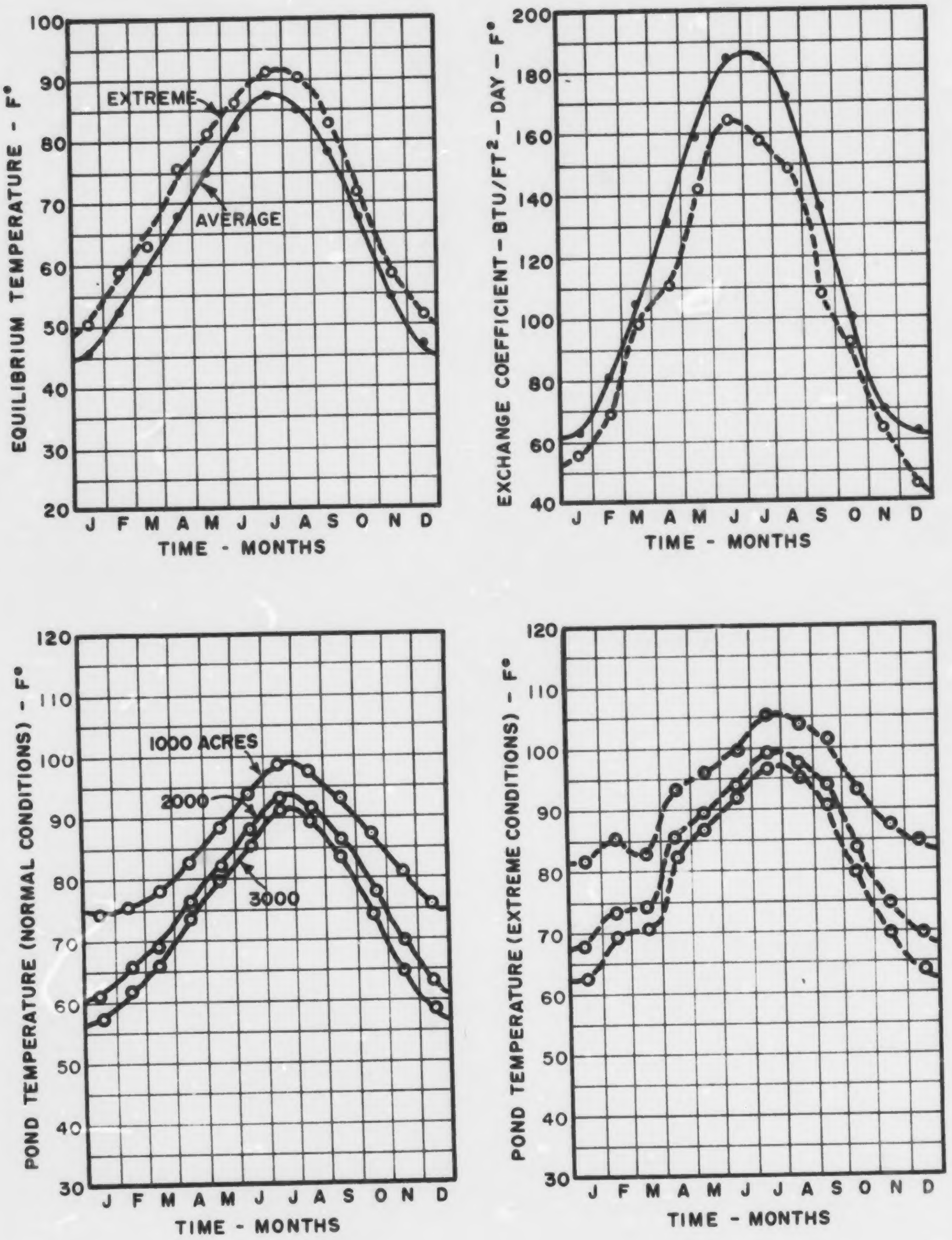

FIGURE 93 - RESULTS FOR LAS VEGAS, NEVADA

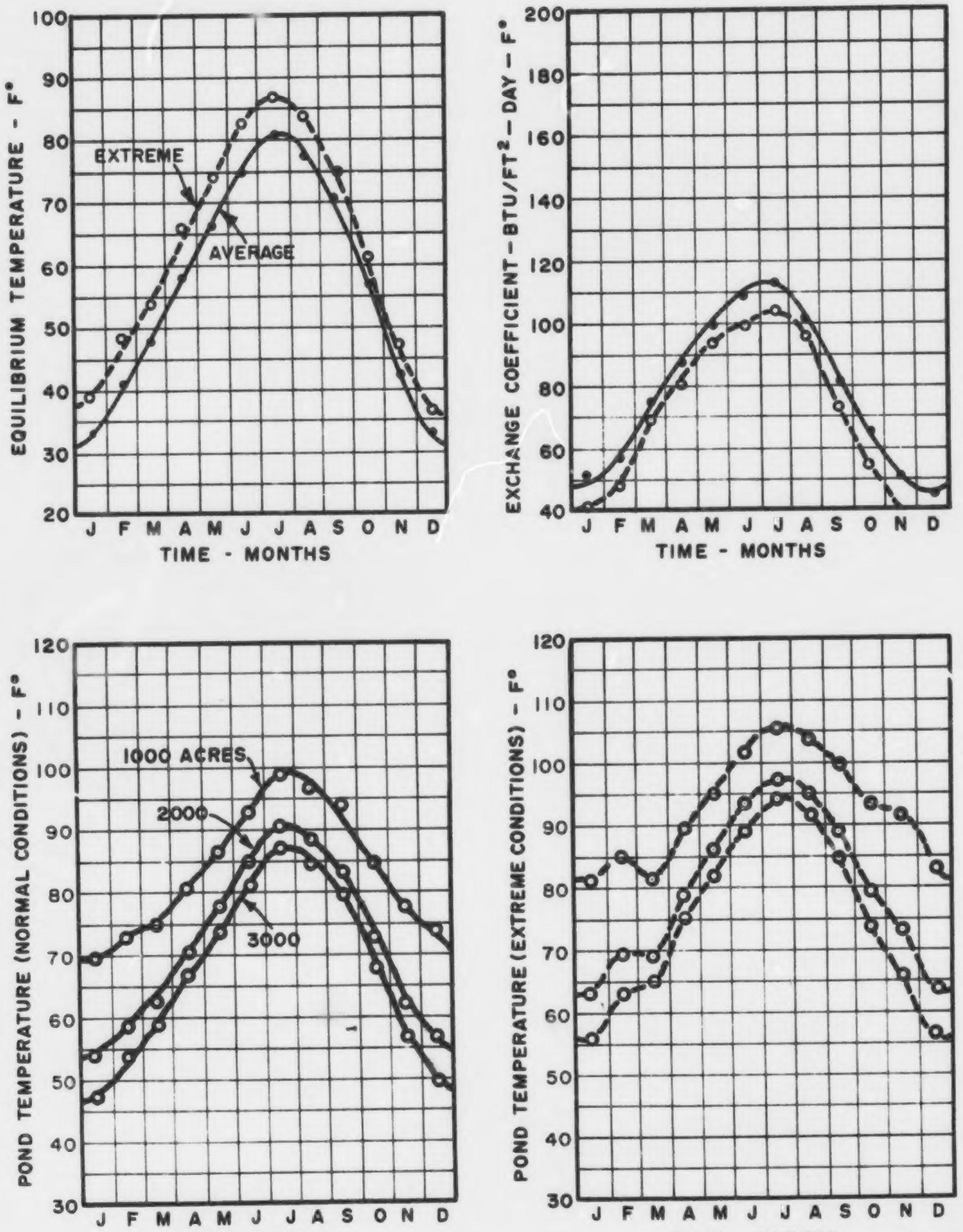

FIGURE 94 - RESULTS FOR RENO, NEVADA

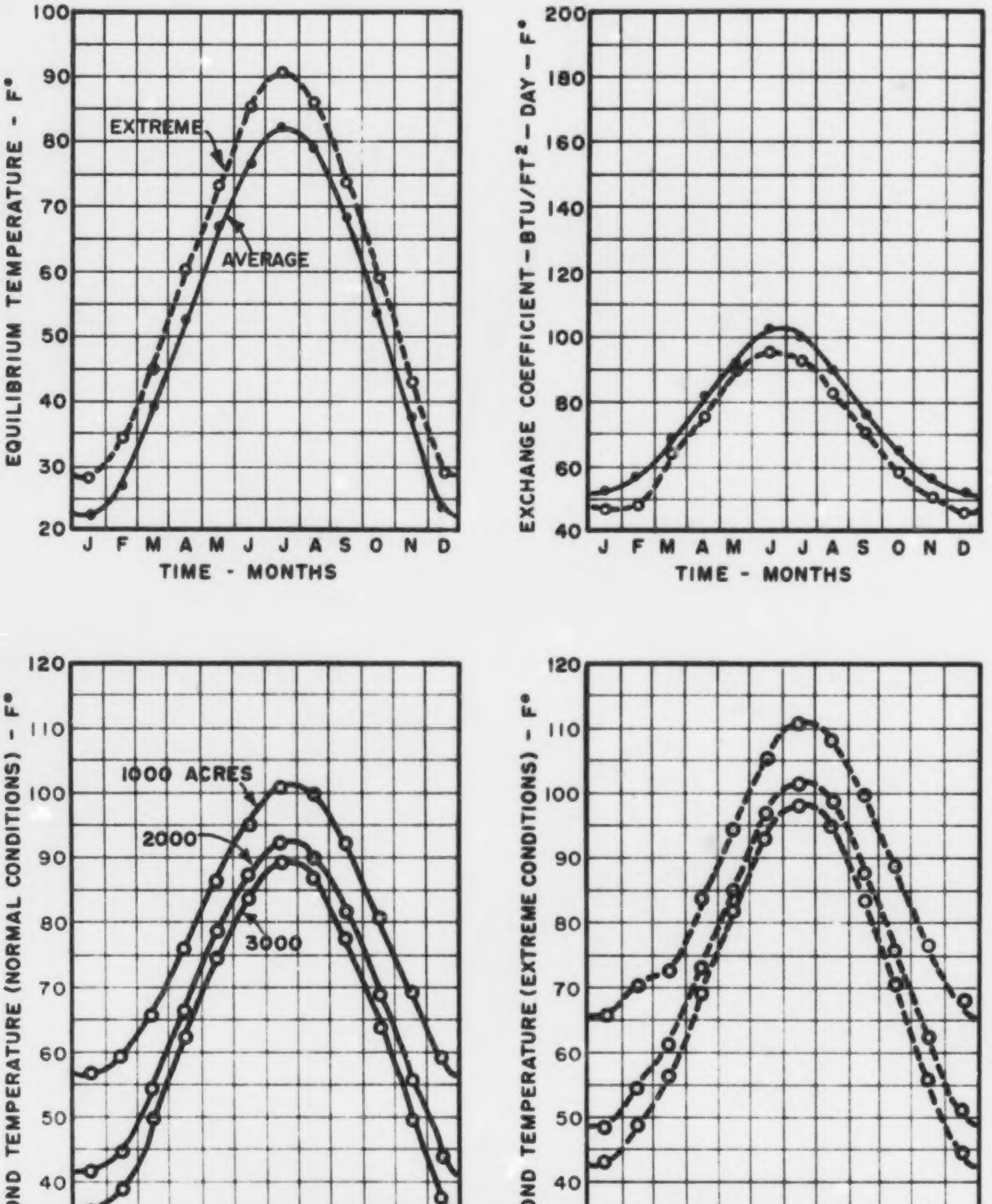

FIGURE 95 - RESULTS FOR CONCORD, NEW HAMPSHIRE

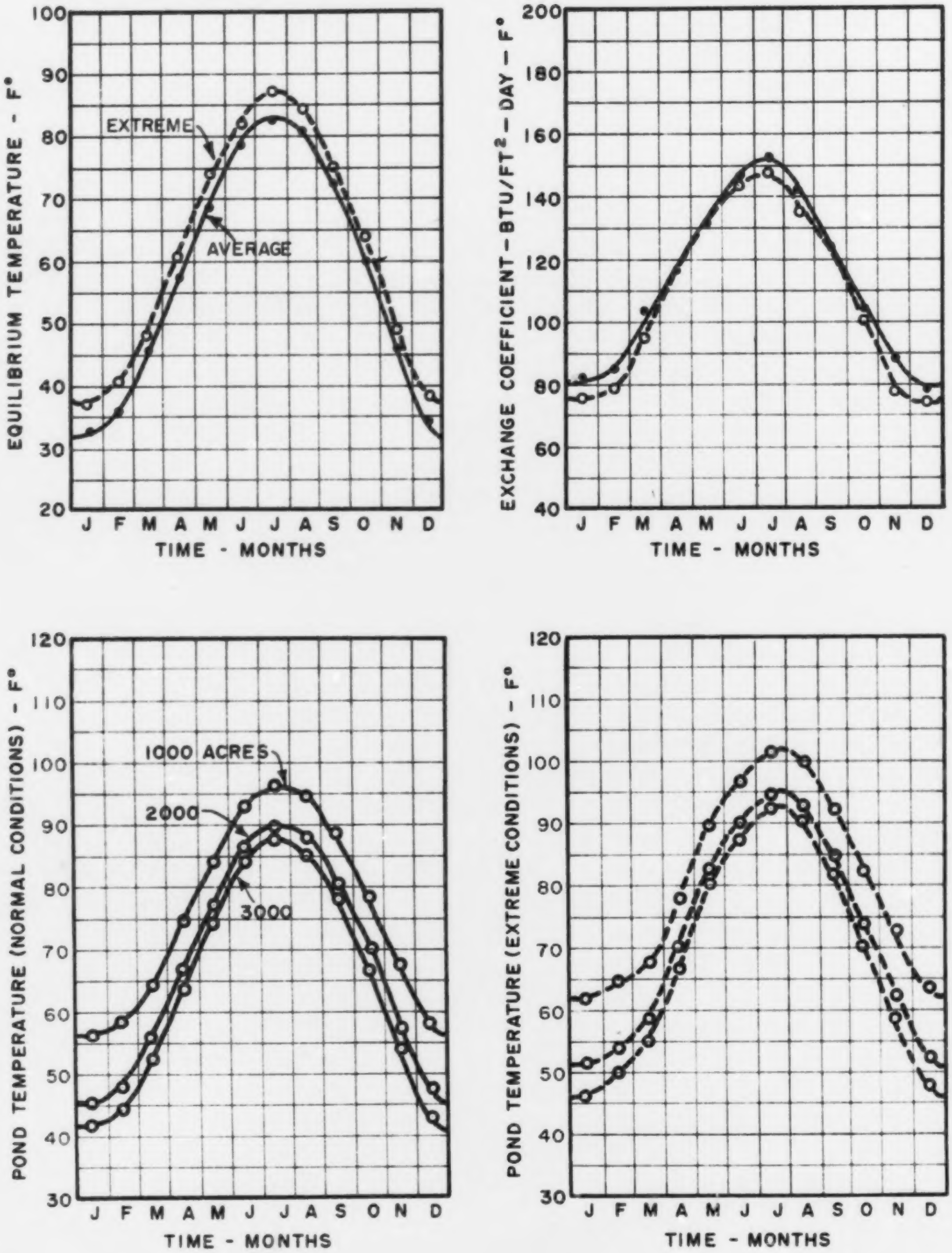

FIGURE 96 - RESULTS FOR NEWARK, NEW JERSEY

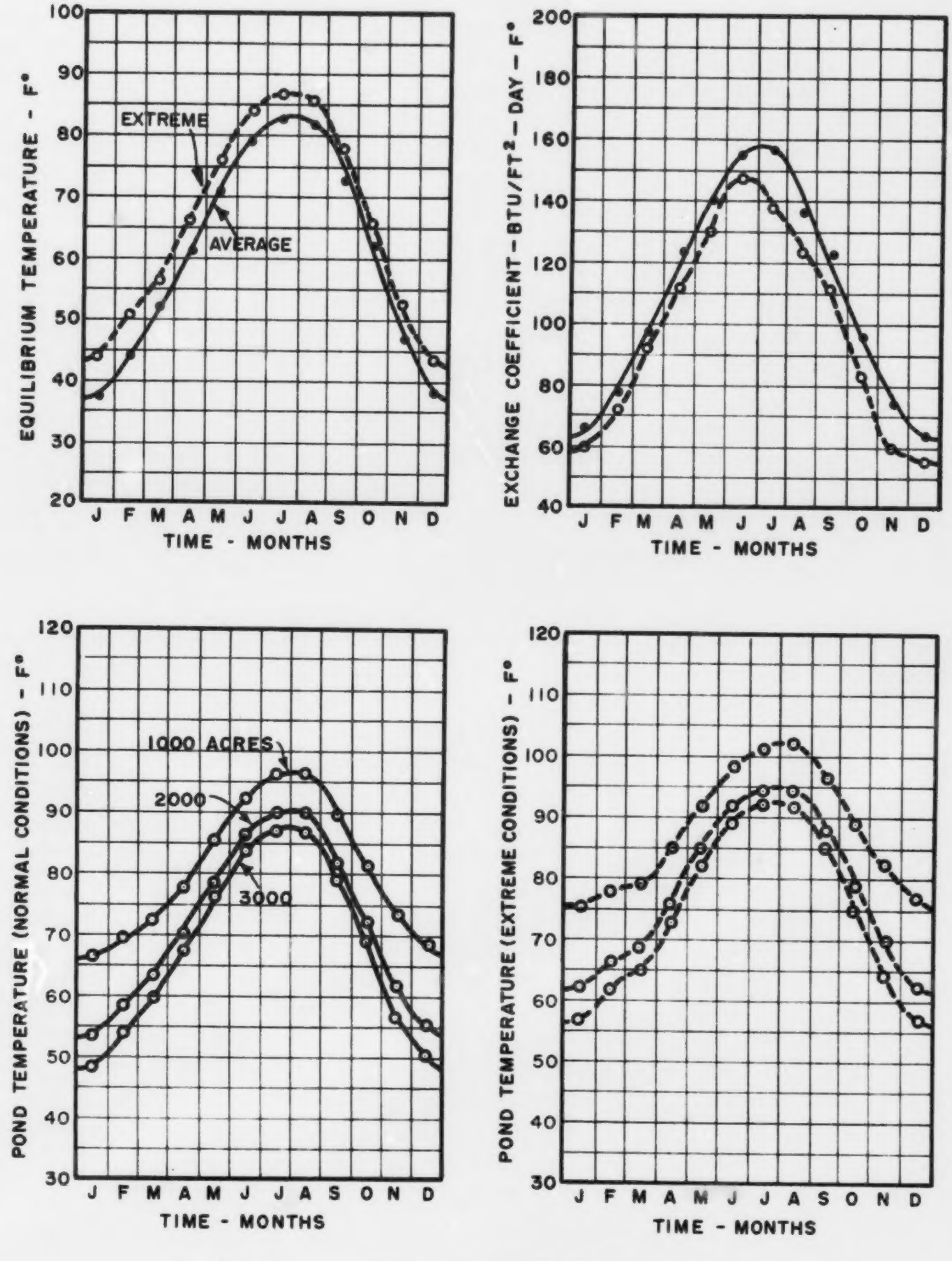

FIGURE 97 - RESULTS FOR ALBUQUERQUE, NEW MEXICO

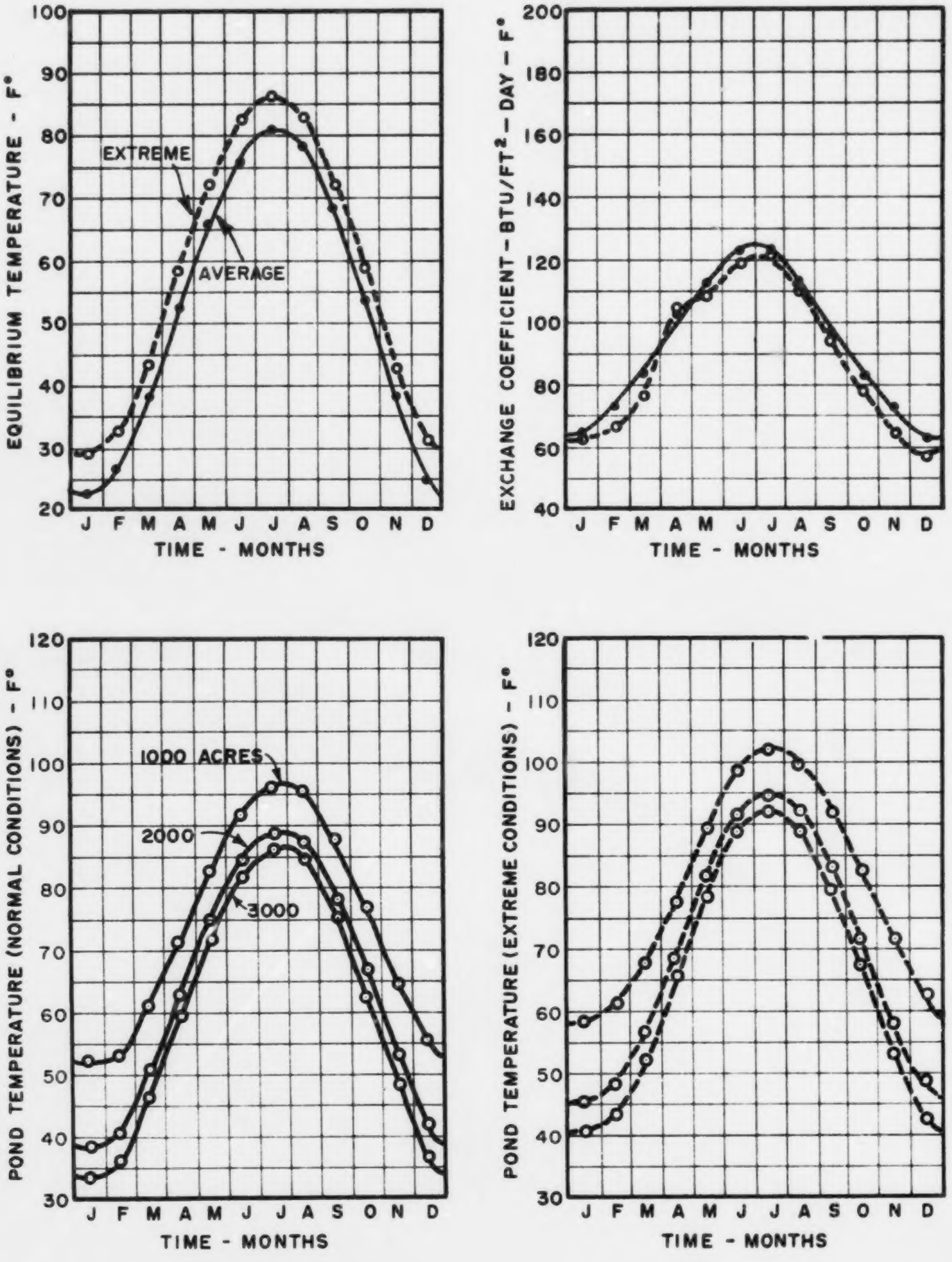

FIGURE 98 - RESULTS FOR ALBANY, NEW YORK

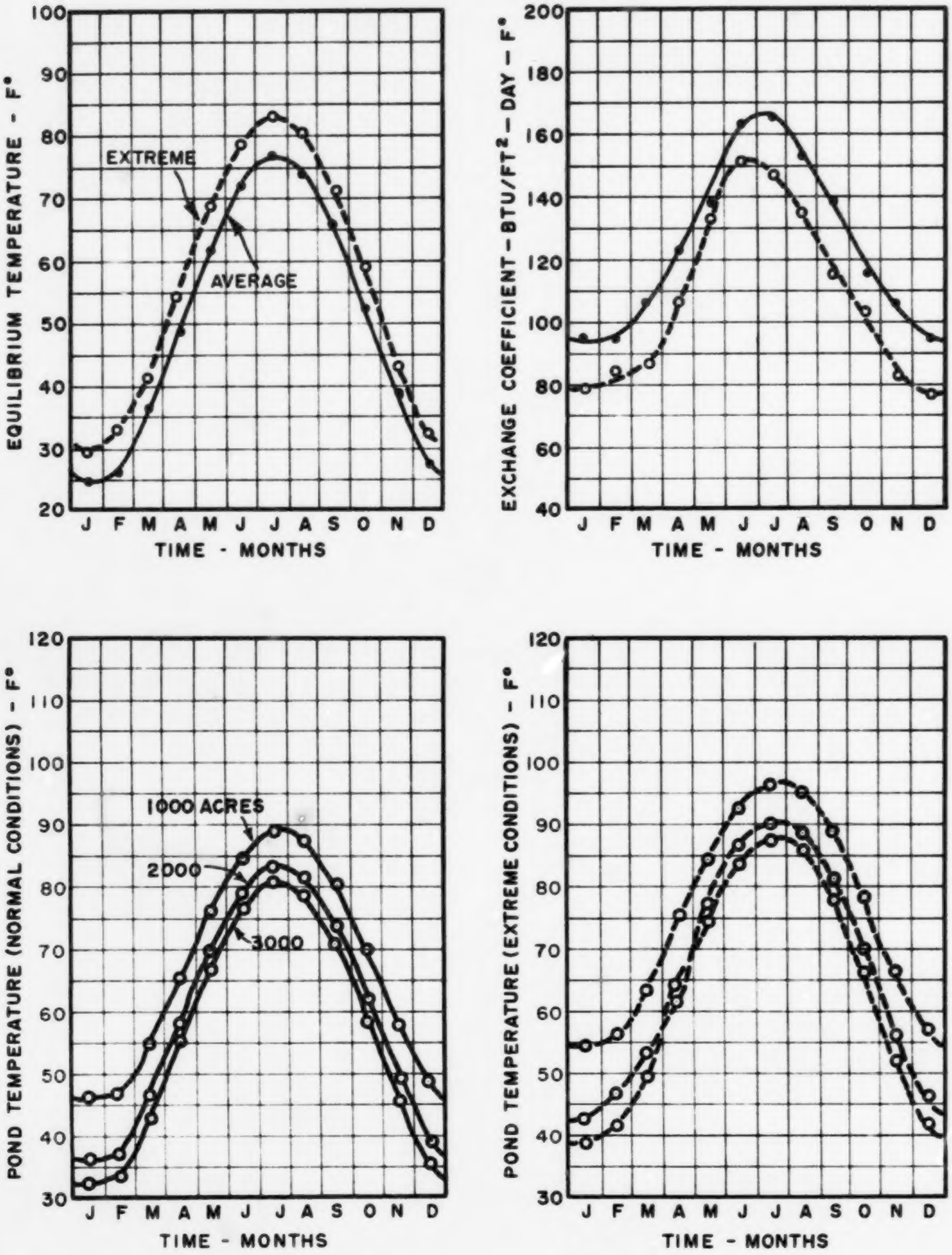

FIGURE 99 - RESULTS FOR BUFFALO, NEW YORK

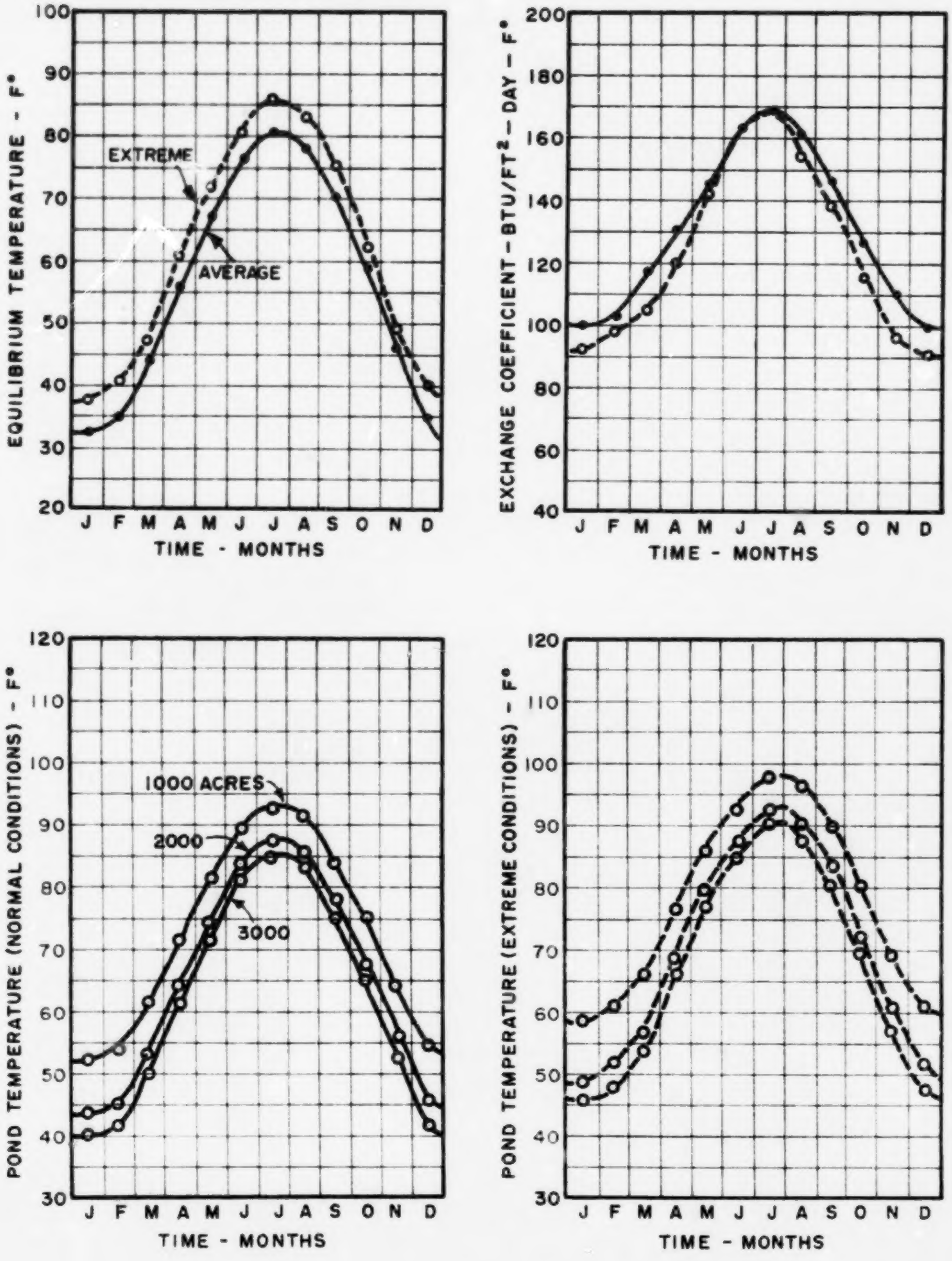

FIGURE 100- RESULTS FOR NEW YORK, NEW YORK

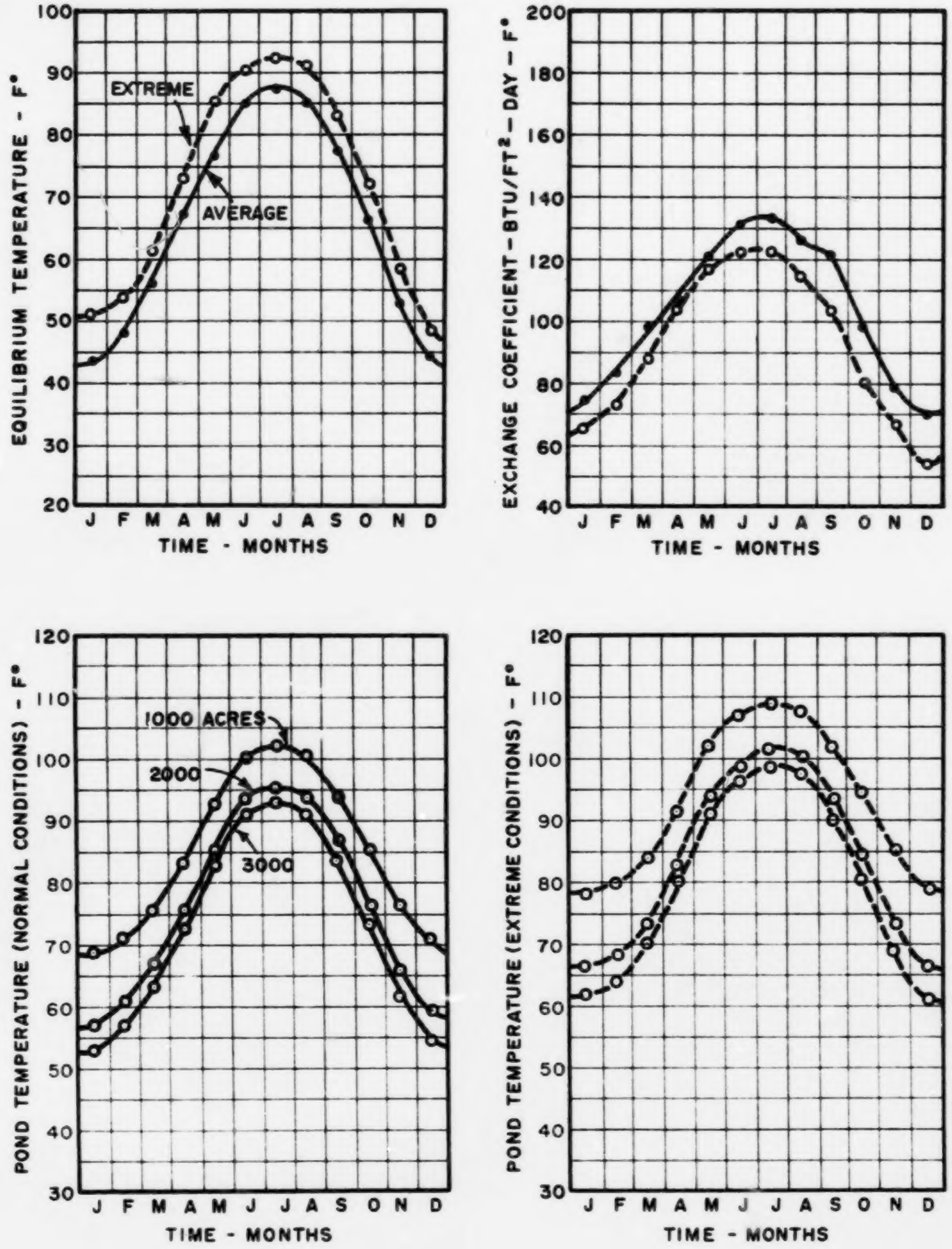

FIGURE 101 - RESULTS FOR CHARLOTTE, NORTH CAROLINA

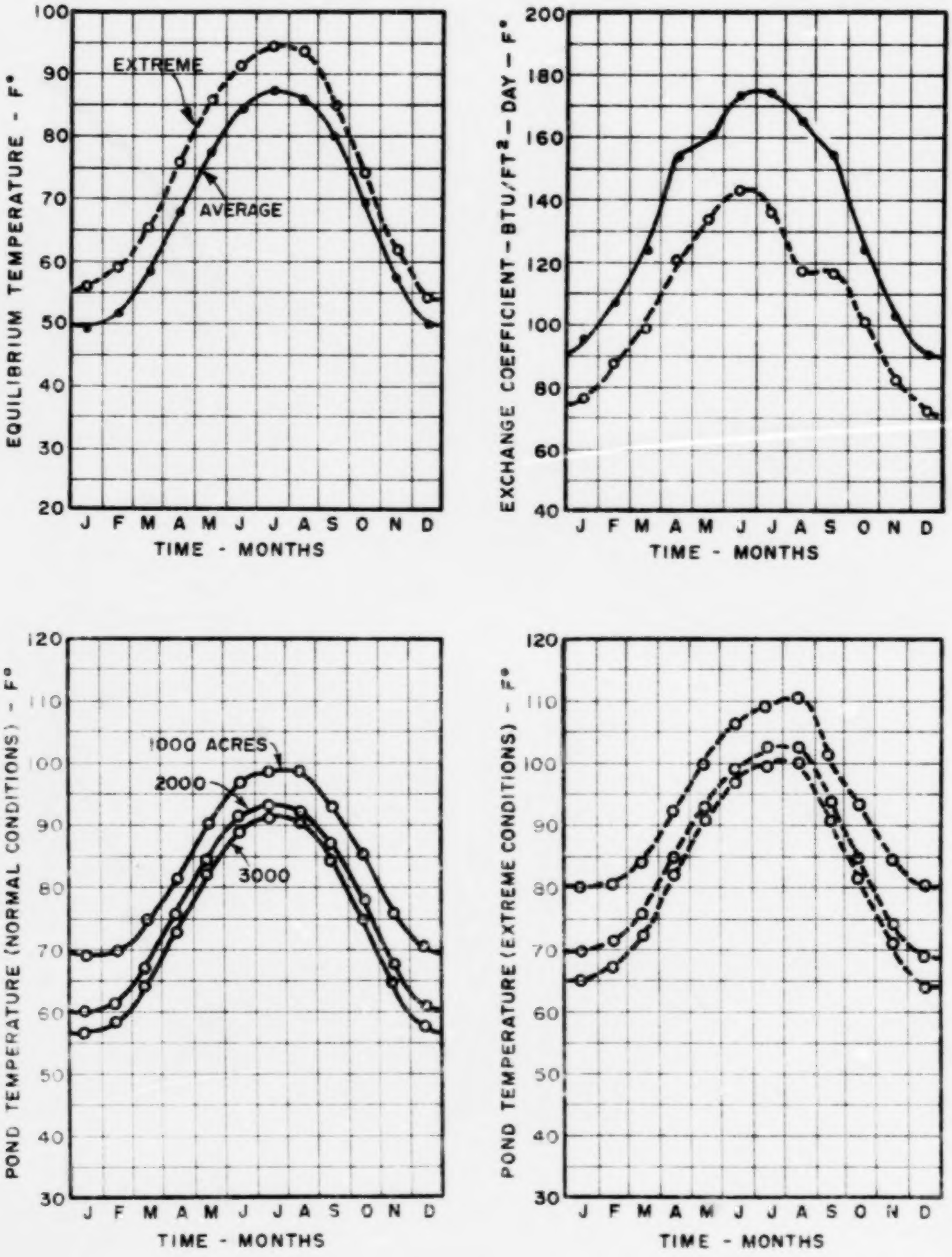

FIGURE 102 - RESULTS FOR WILMINGTON, NORTH CAROLINA

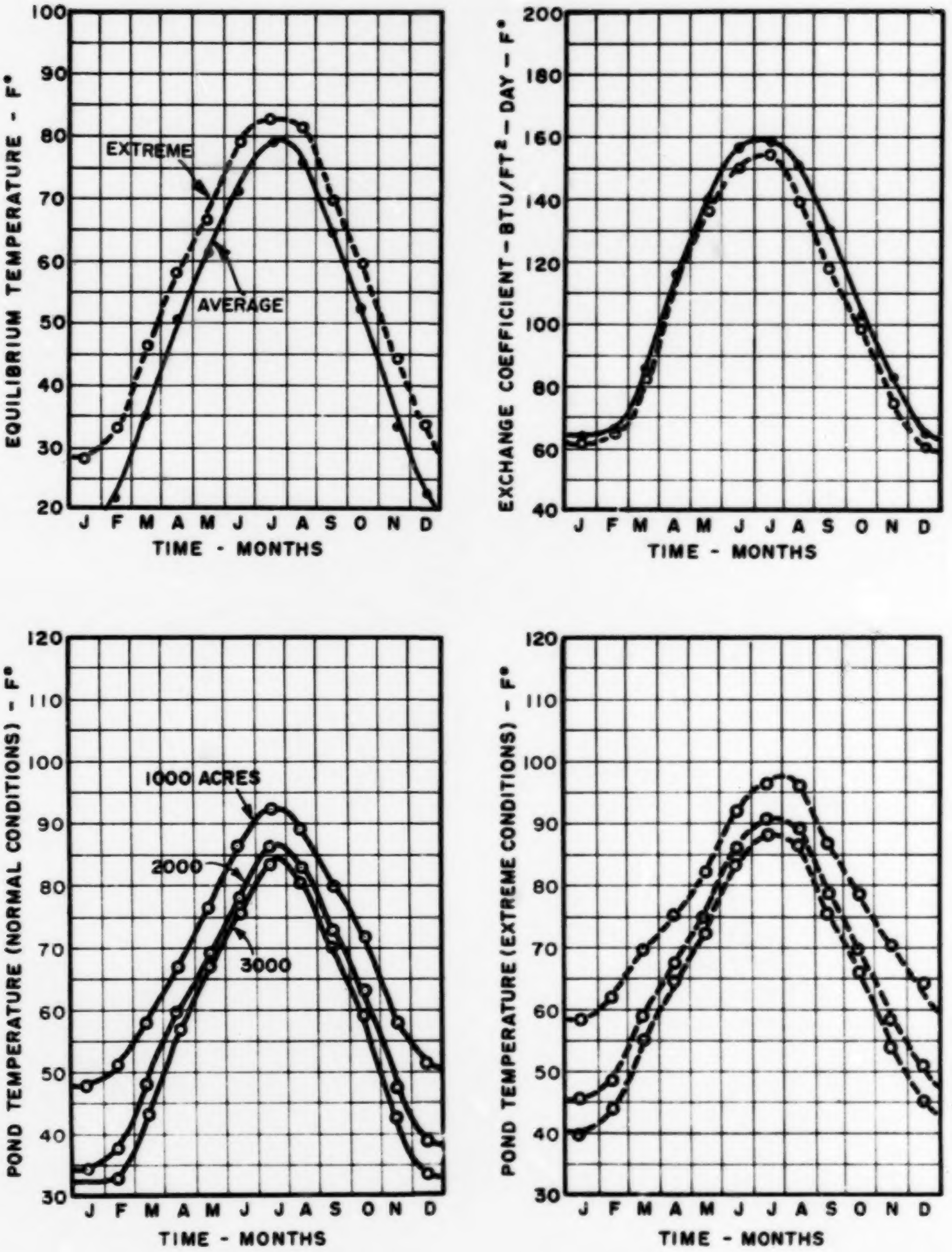

FIGURE 103 - RESULTS FOR BISMARCK, NORTH DAKOTA

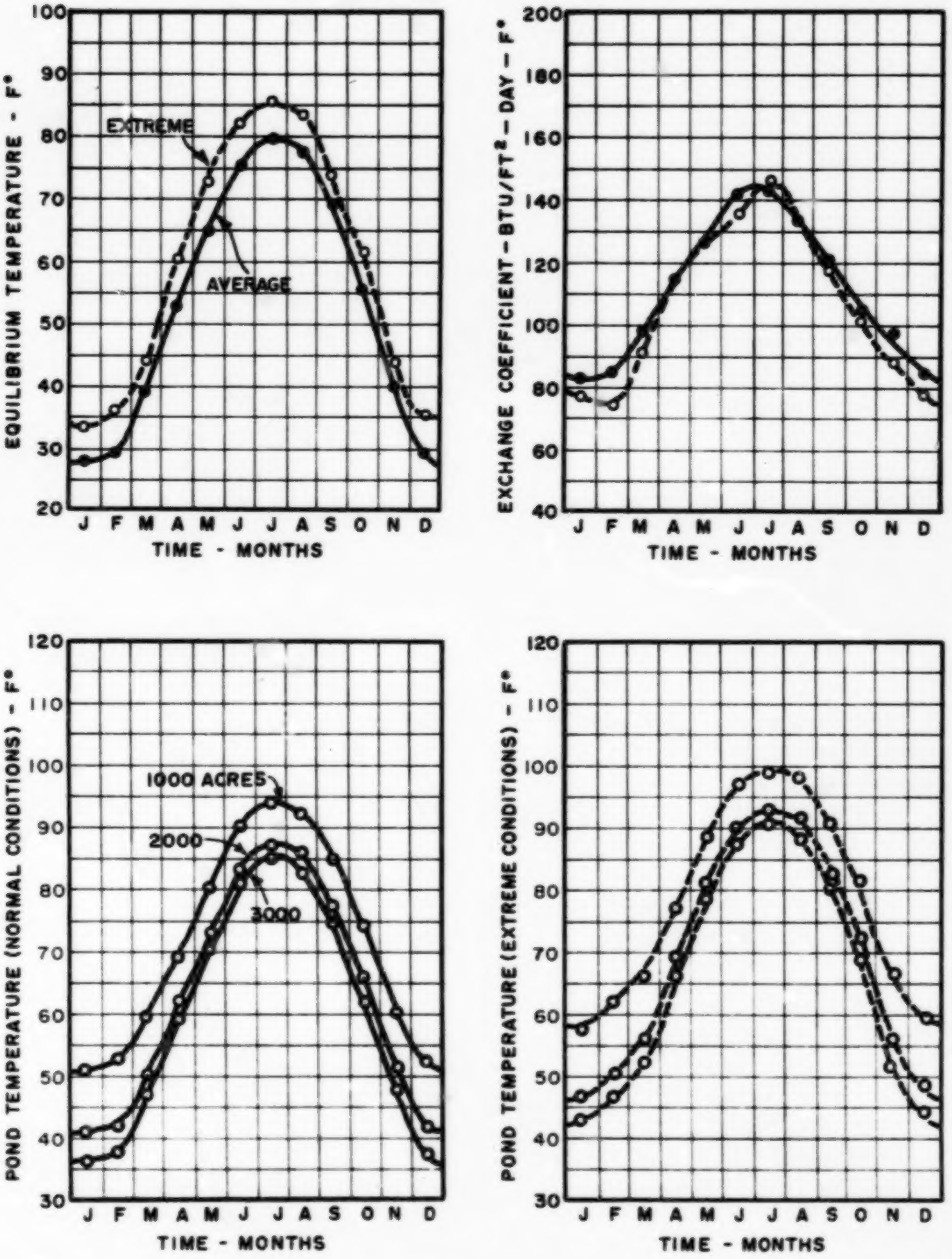

FIGURE 104- RESULTS FOR CLEVELAND, OHIO

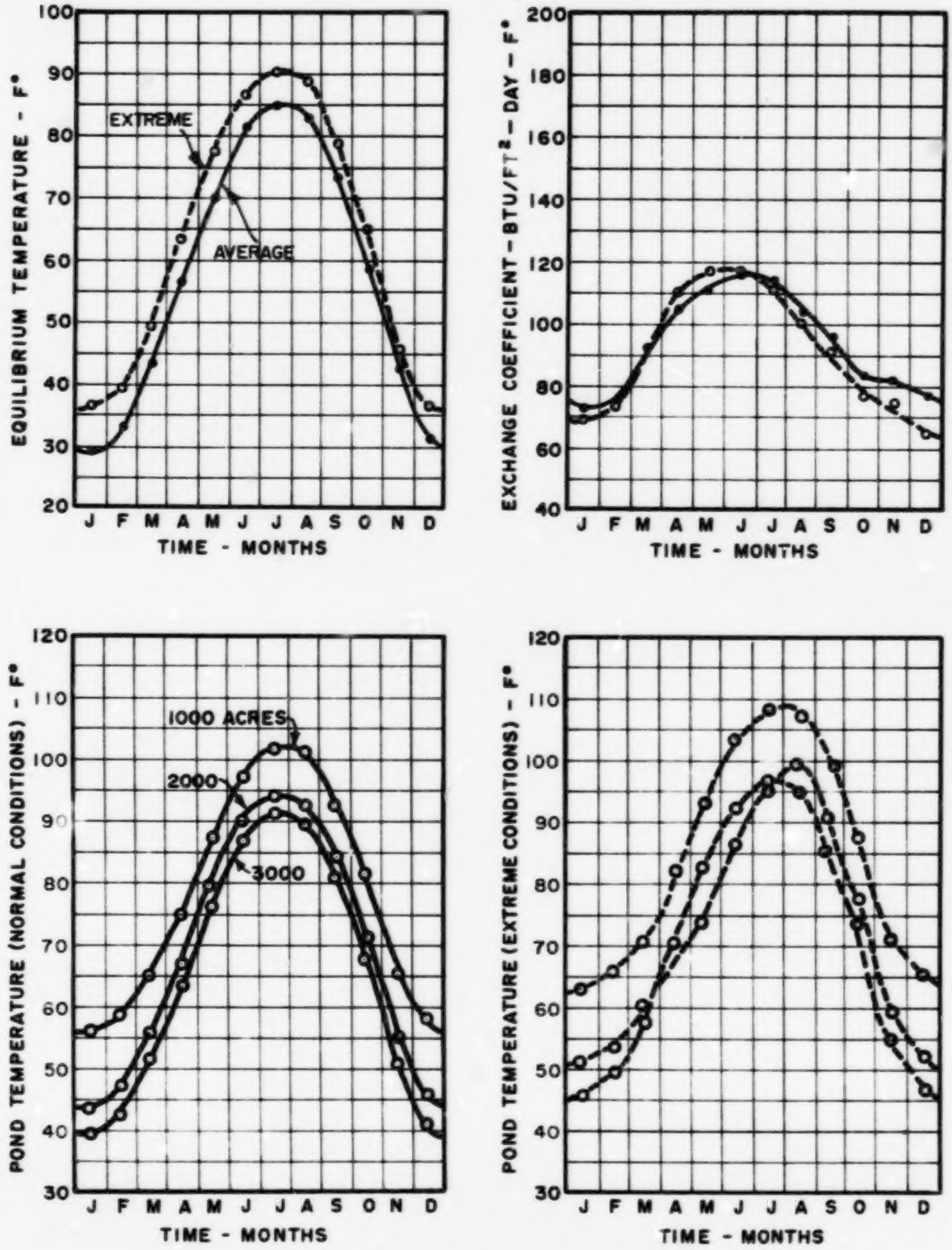

FIGURE 105 - RESULTS FOR COLUMBUS, OHIO

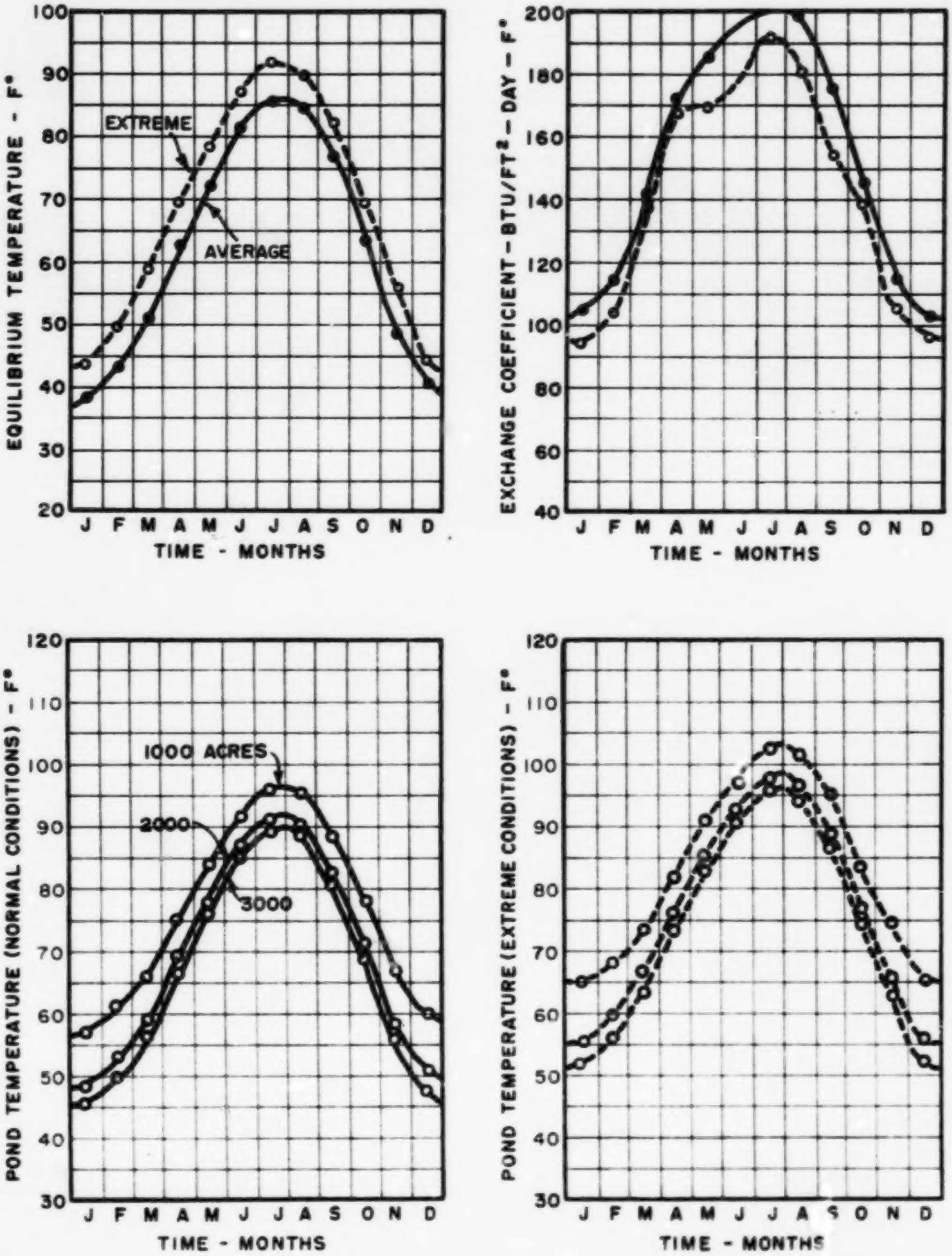

FIGURE 106 - RESULTS FOR OKLAHOMA CITY, OKLAHOMA

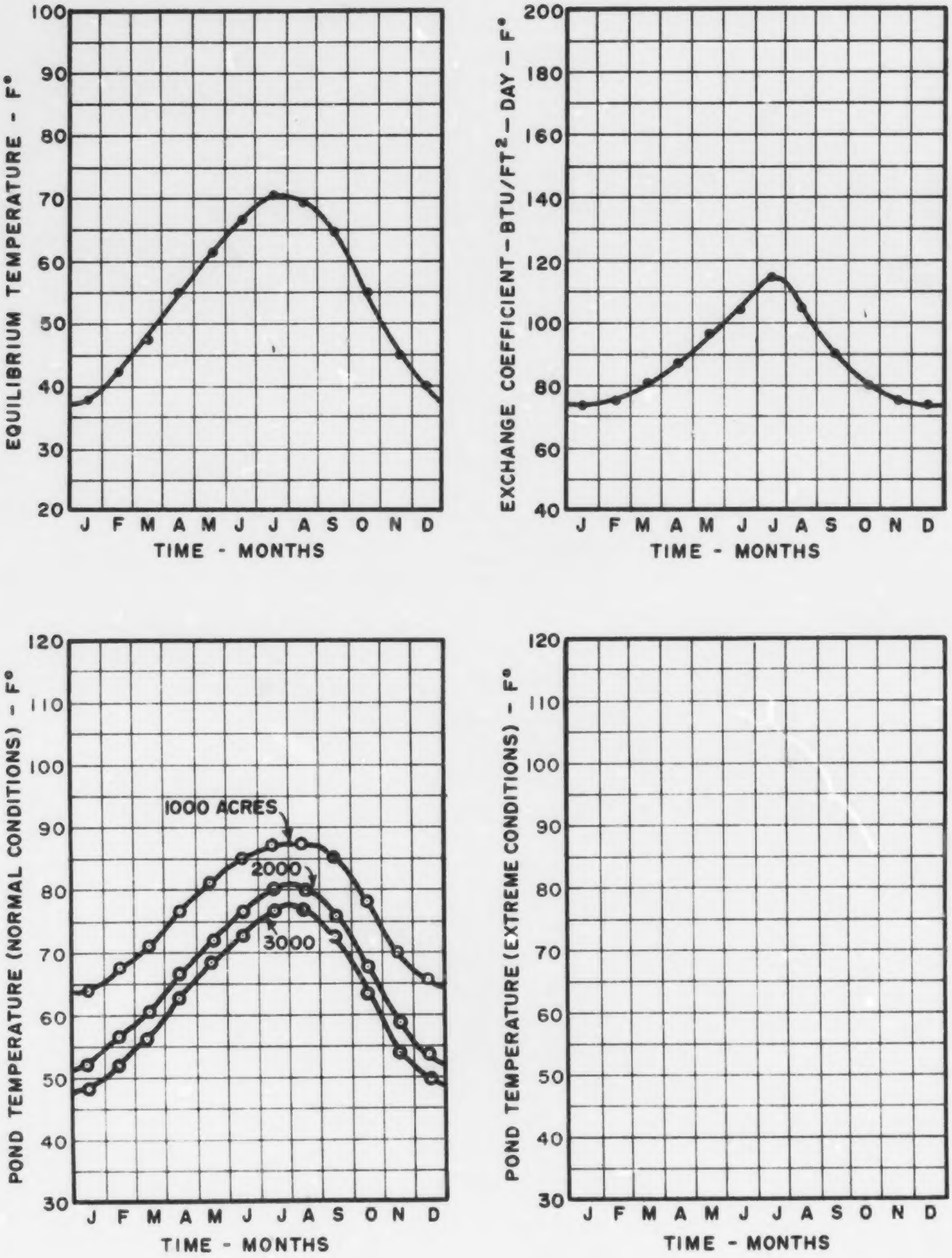

FIGURE 107 - RESULTS FOR ASTORIA, OREGON
(AVERAGE CONDITIONS)

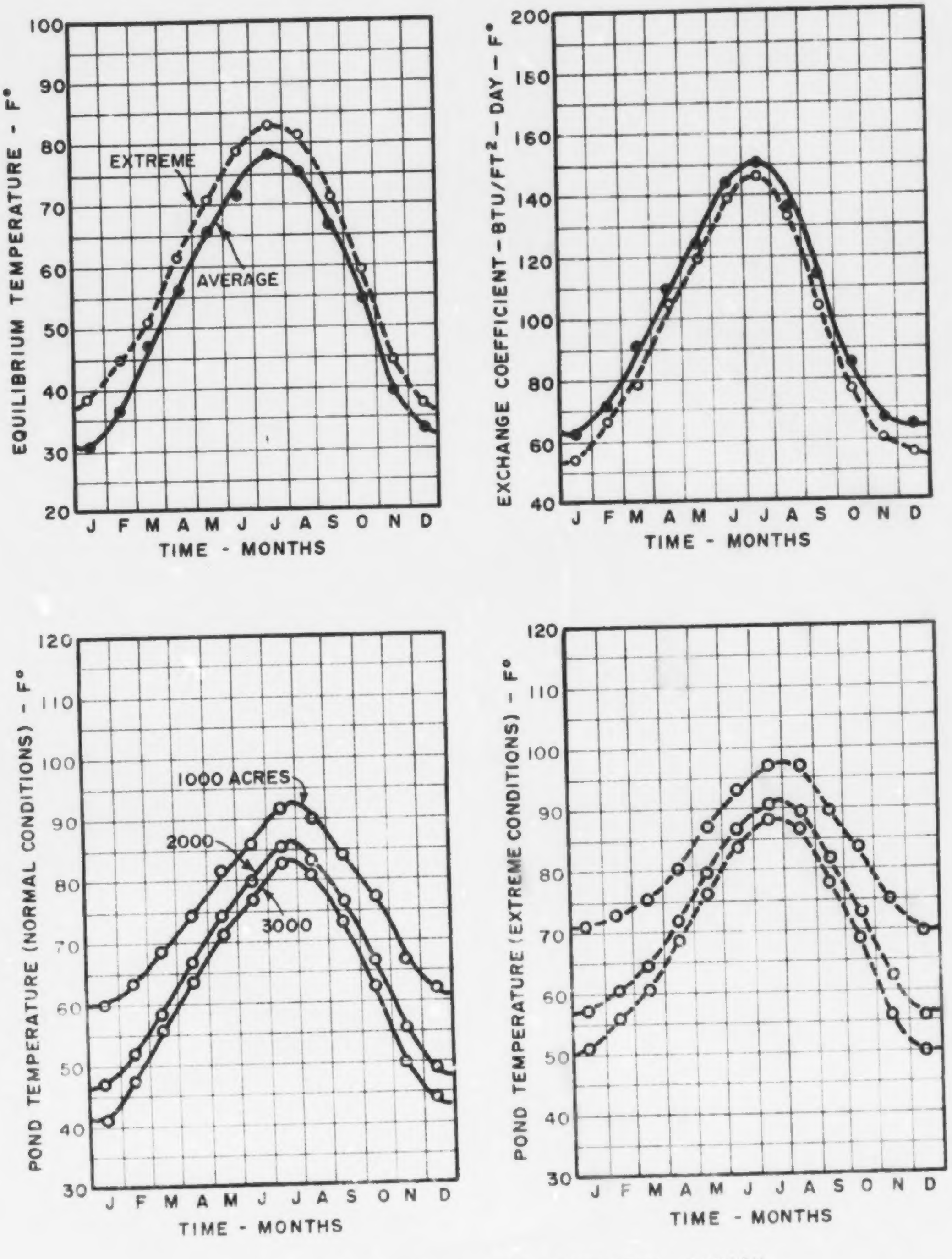

FIGURE 108 - RESULTS FOR PENDLETON, OREGON

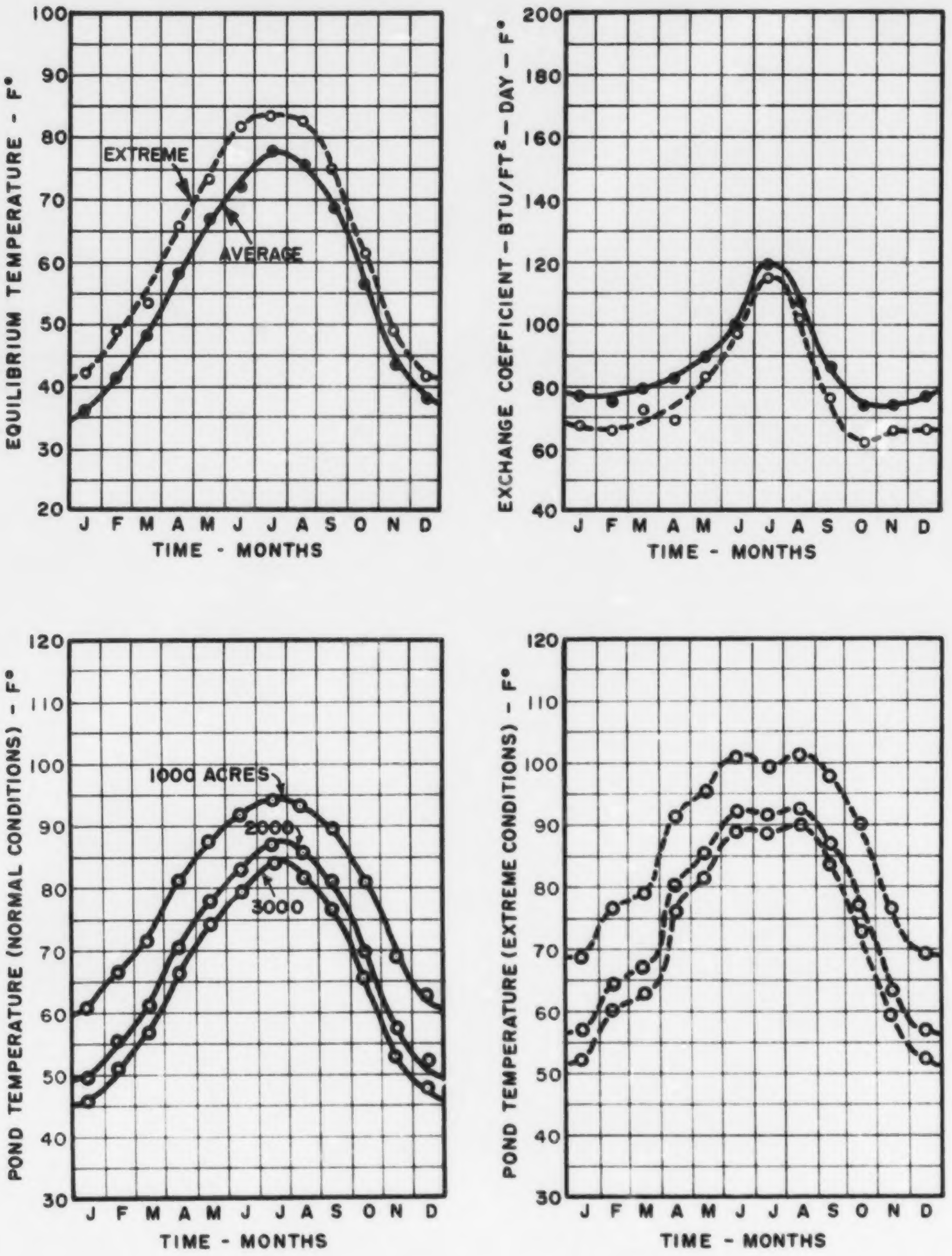

FIGURE 109 - RESULTS FOR PORTLAND, OREGON

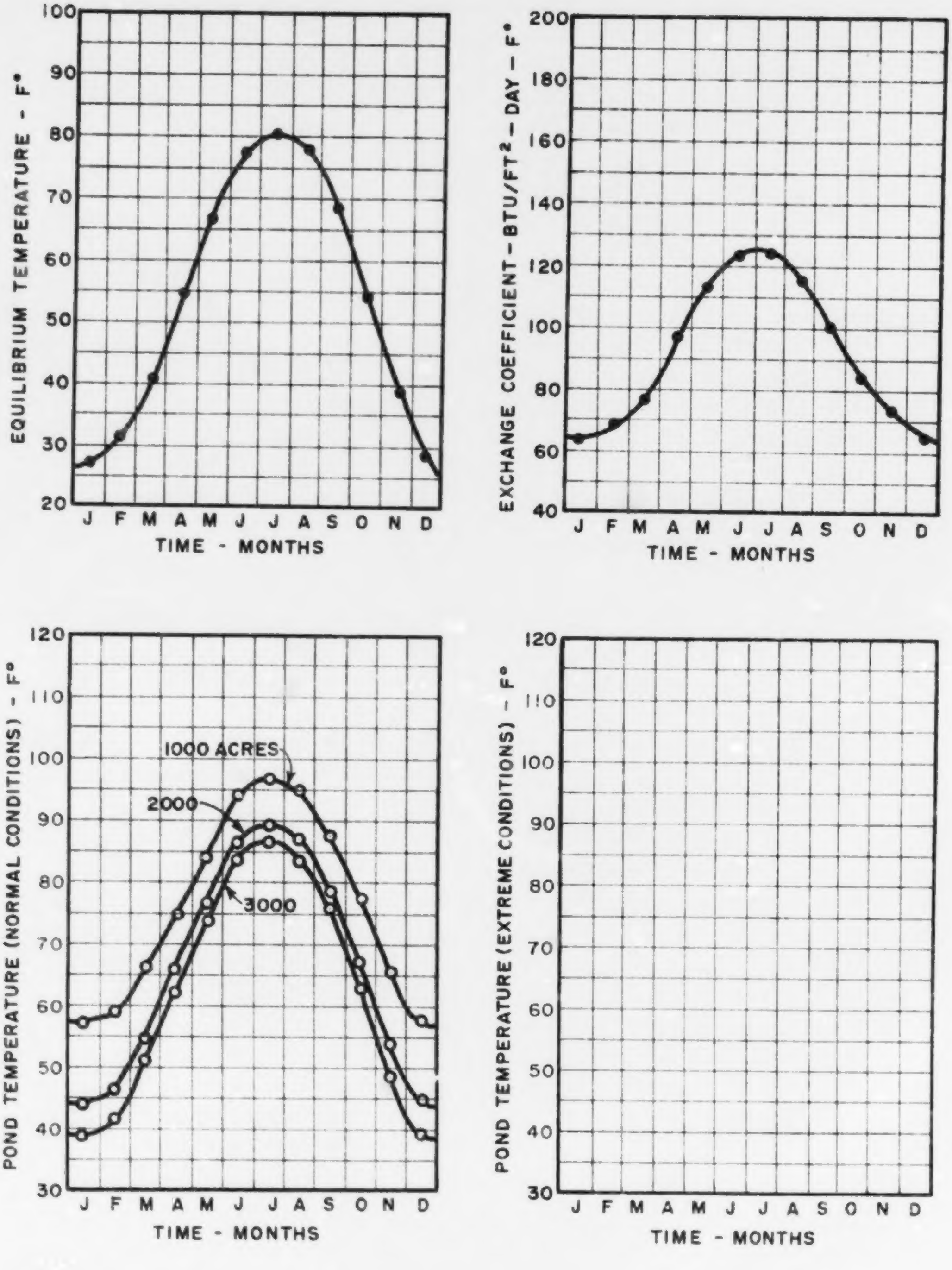

FIGURE 110 - RESULTS FOR AVOCA, PENNSYLVANIA
(AVERAGE CONDITIONS)

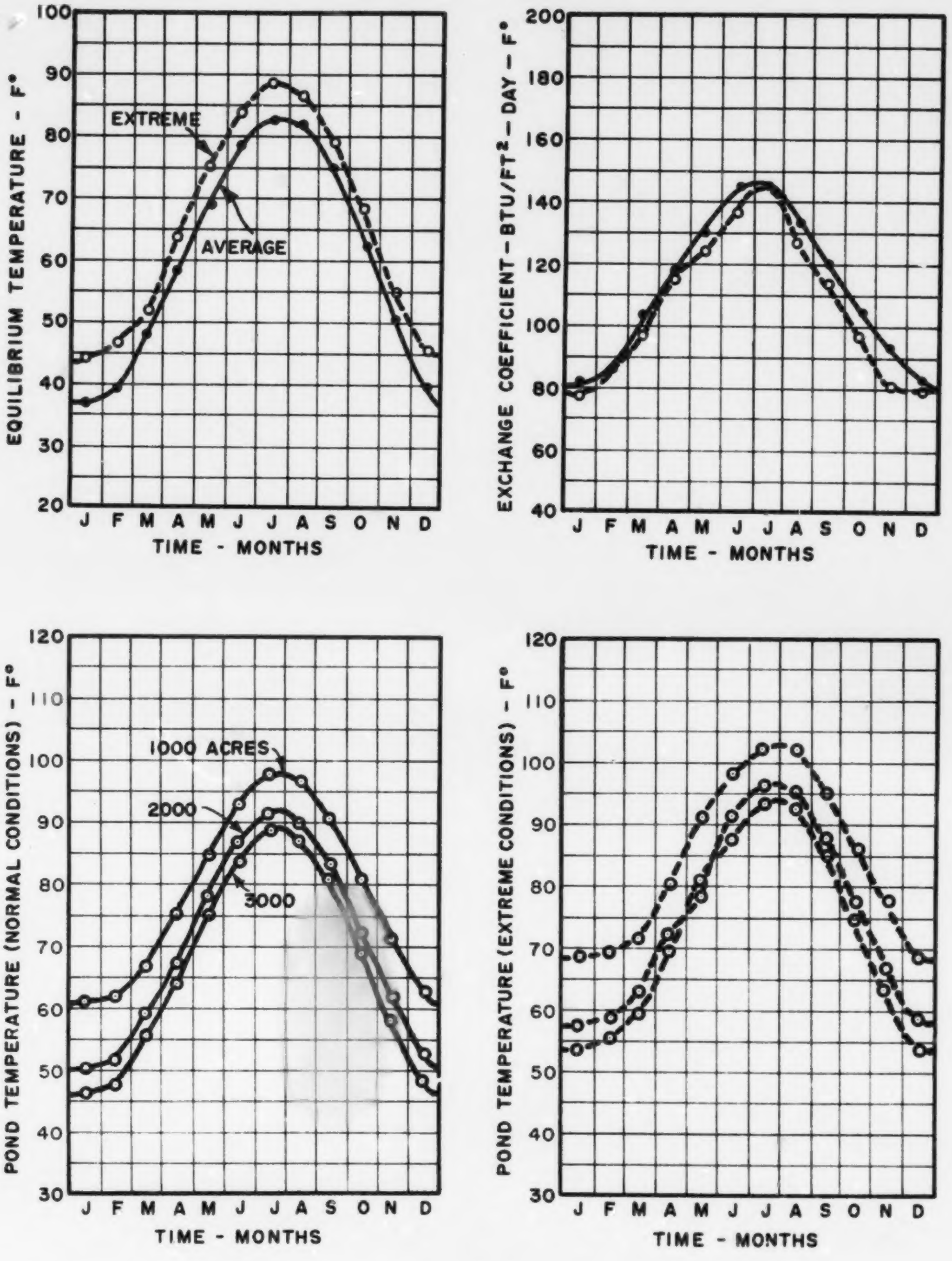

FIGURE 111 - RESULTS FOR PHILADELPHIA, PENNSYLVANIA

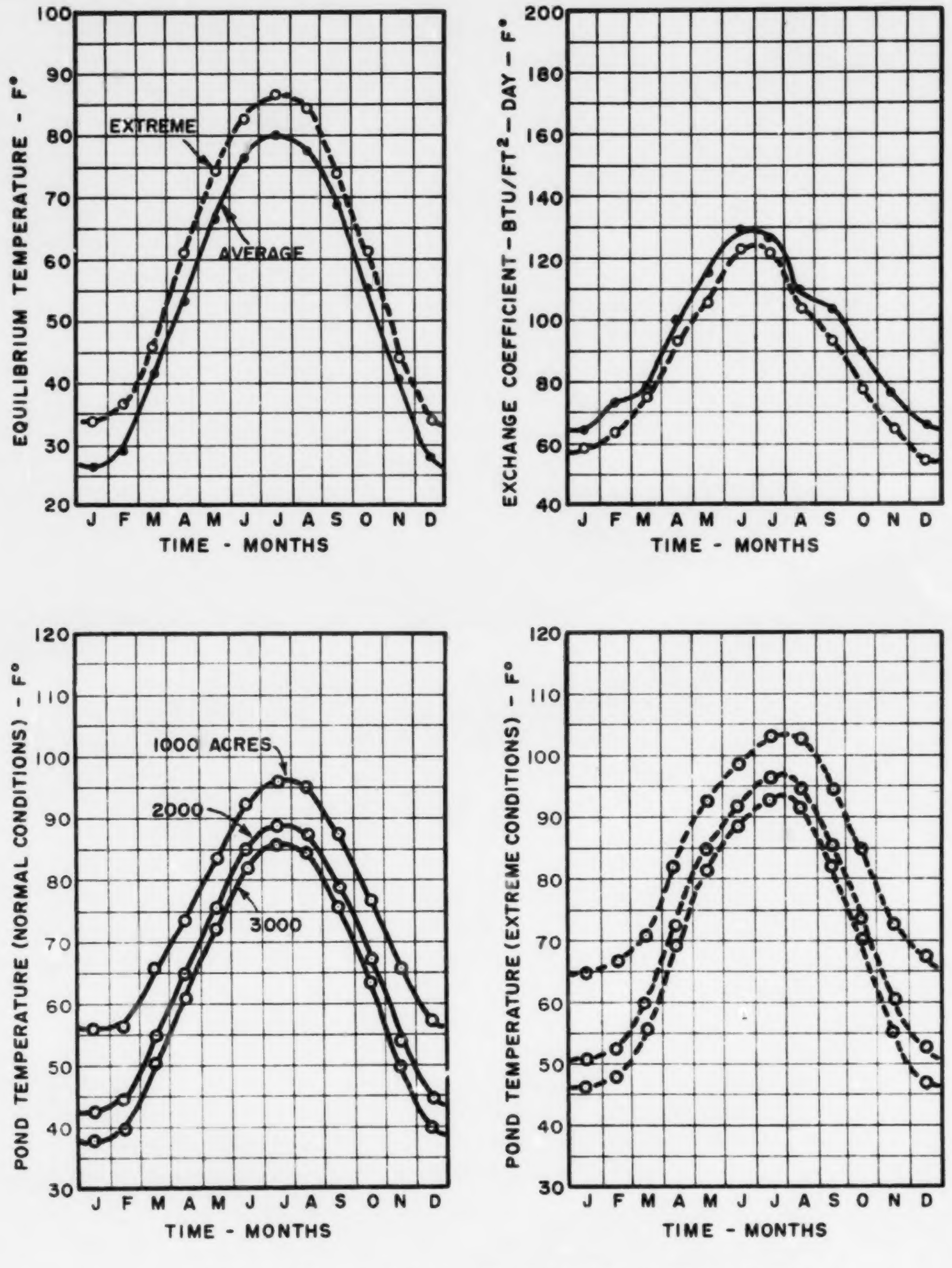

FIGURE 112 - RESULTS FOR SCRANTON, PENNSYLVANIA

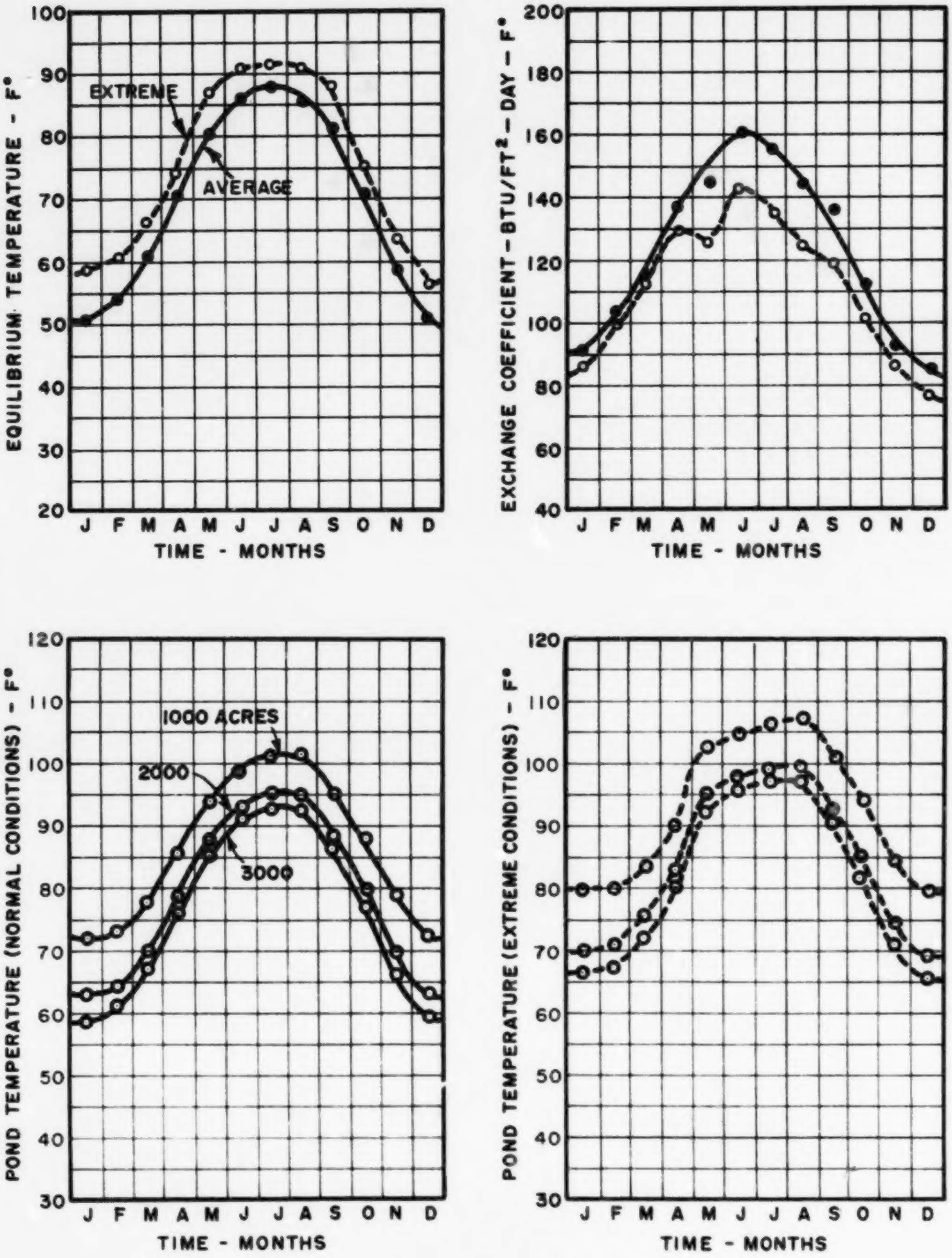

FIGURE 113 - RESULTS FOR CHARLESTON, SOUTH CAROLINA

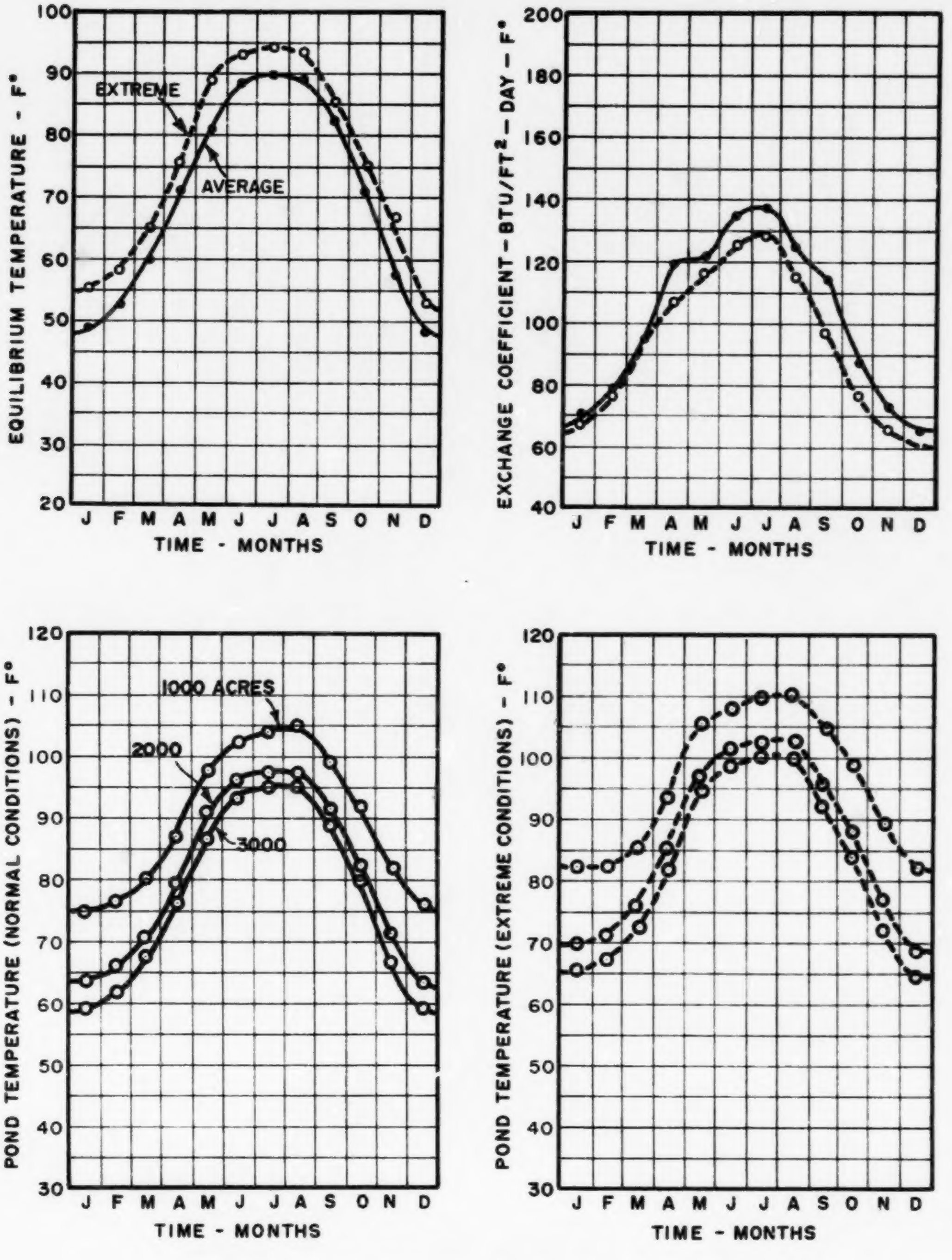

FIGURE 114 - RESULTS FOR COLUMBIA, SOUTH CAROLINA

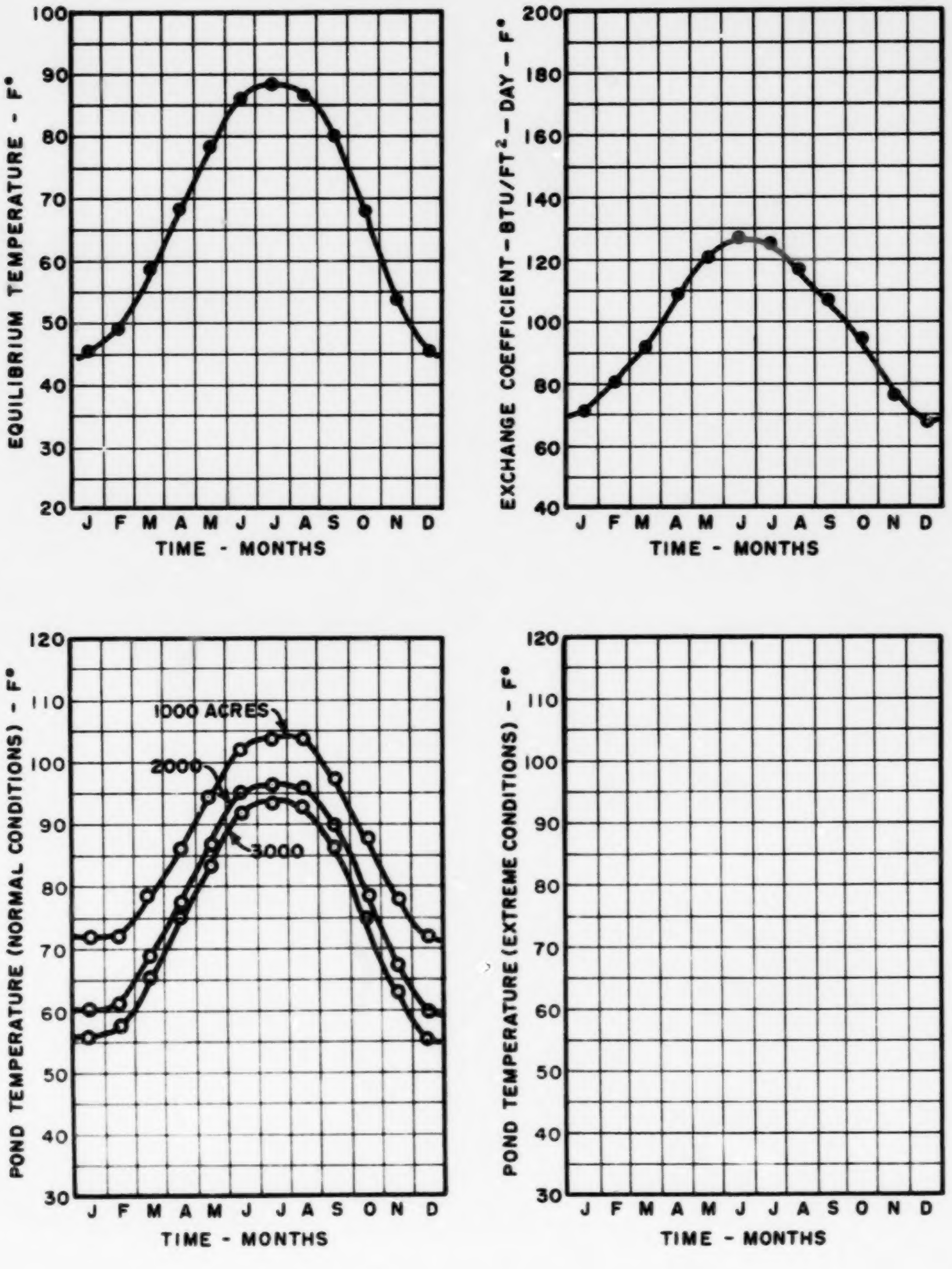

FIGURE 115 - RESULTS FOR GREER, SOUTH CAROLINA, (AVERAGE CONDITIONS)

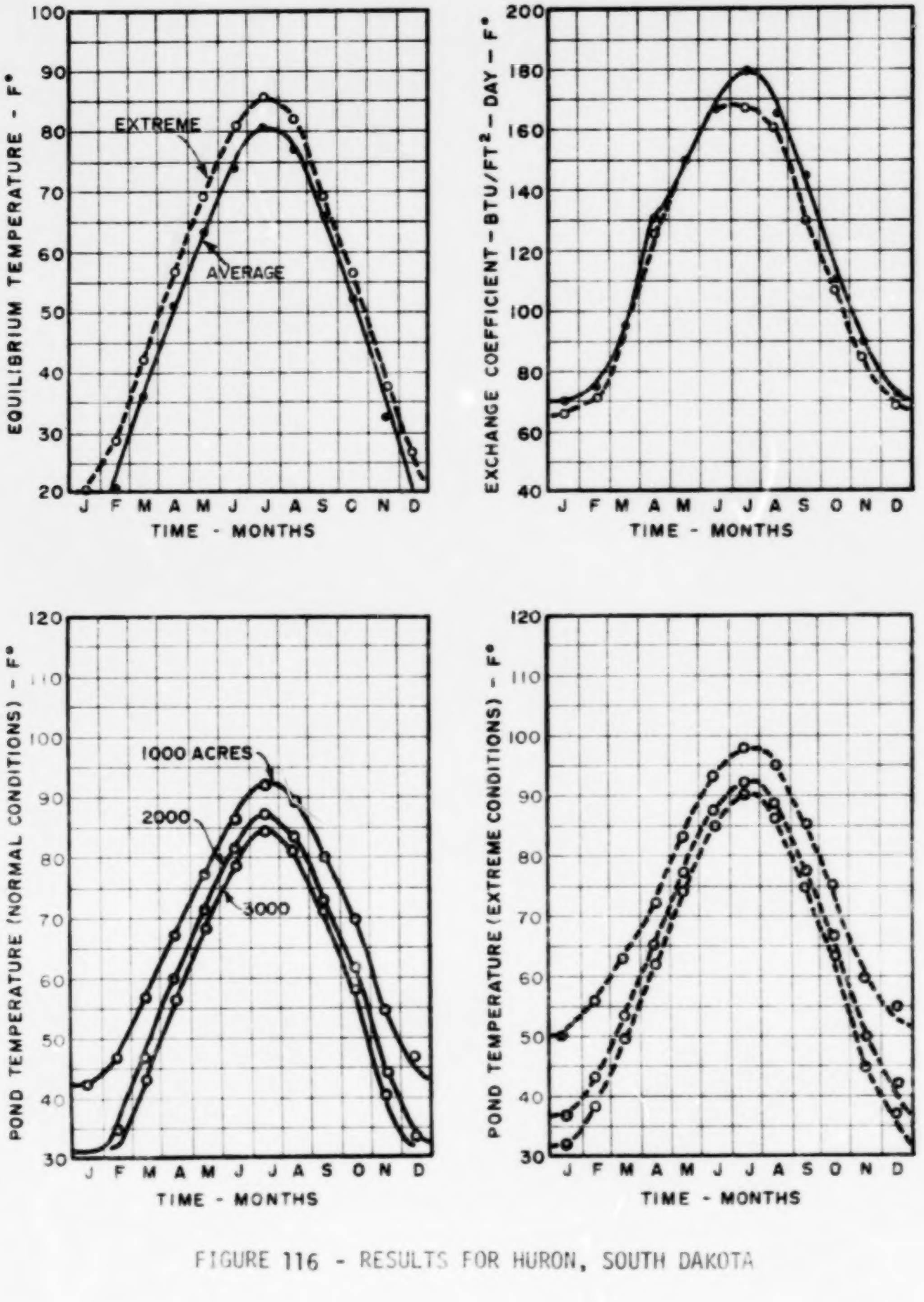

FIGURE 116 - RESULTS FOR HURON, SOUTH DAKOTA

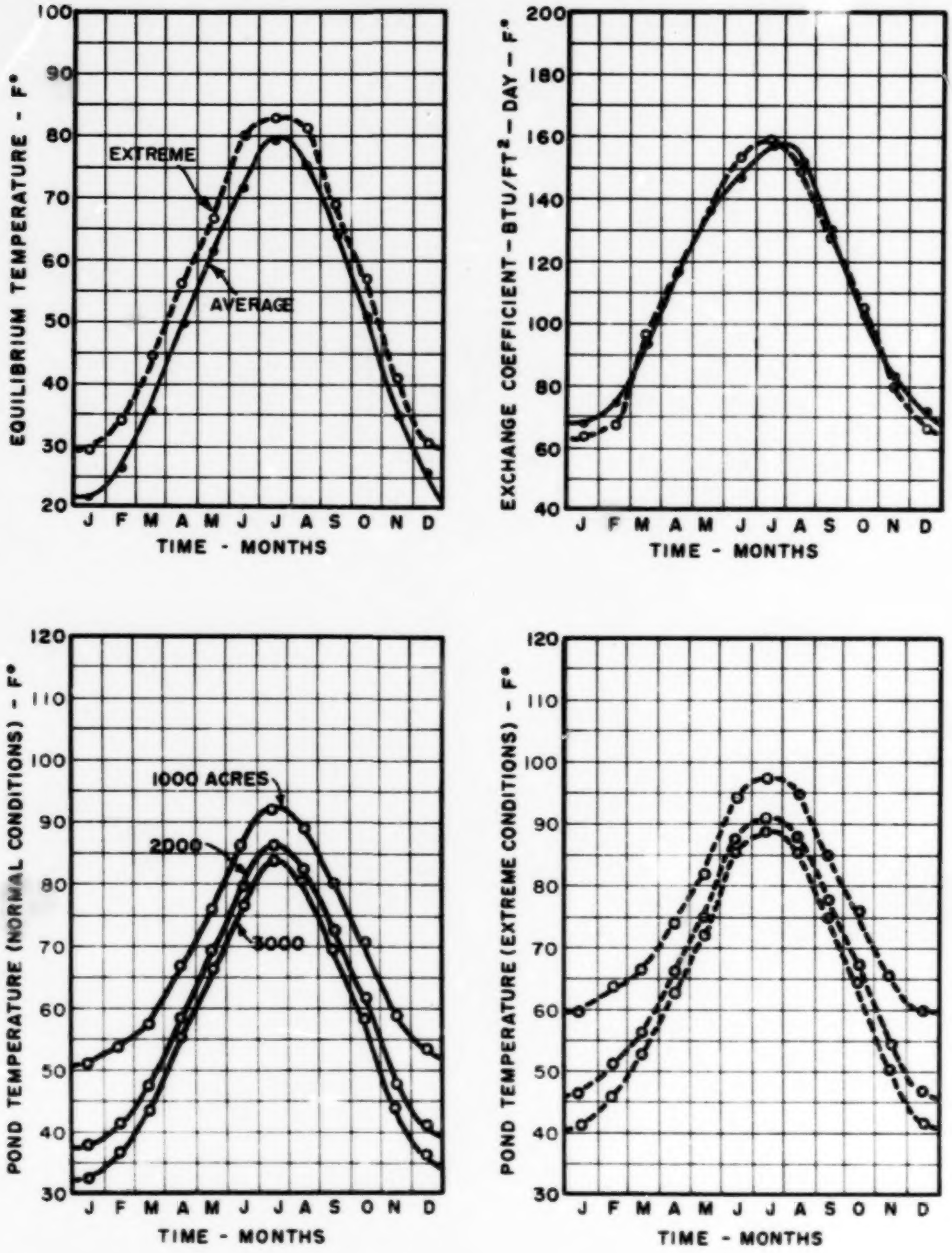

FIGURE 117 - RESULTS FOR RAPID CITY, SOUTH DAKOTA

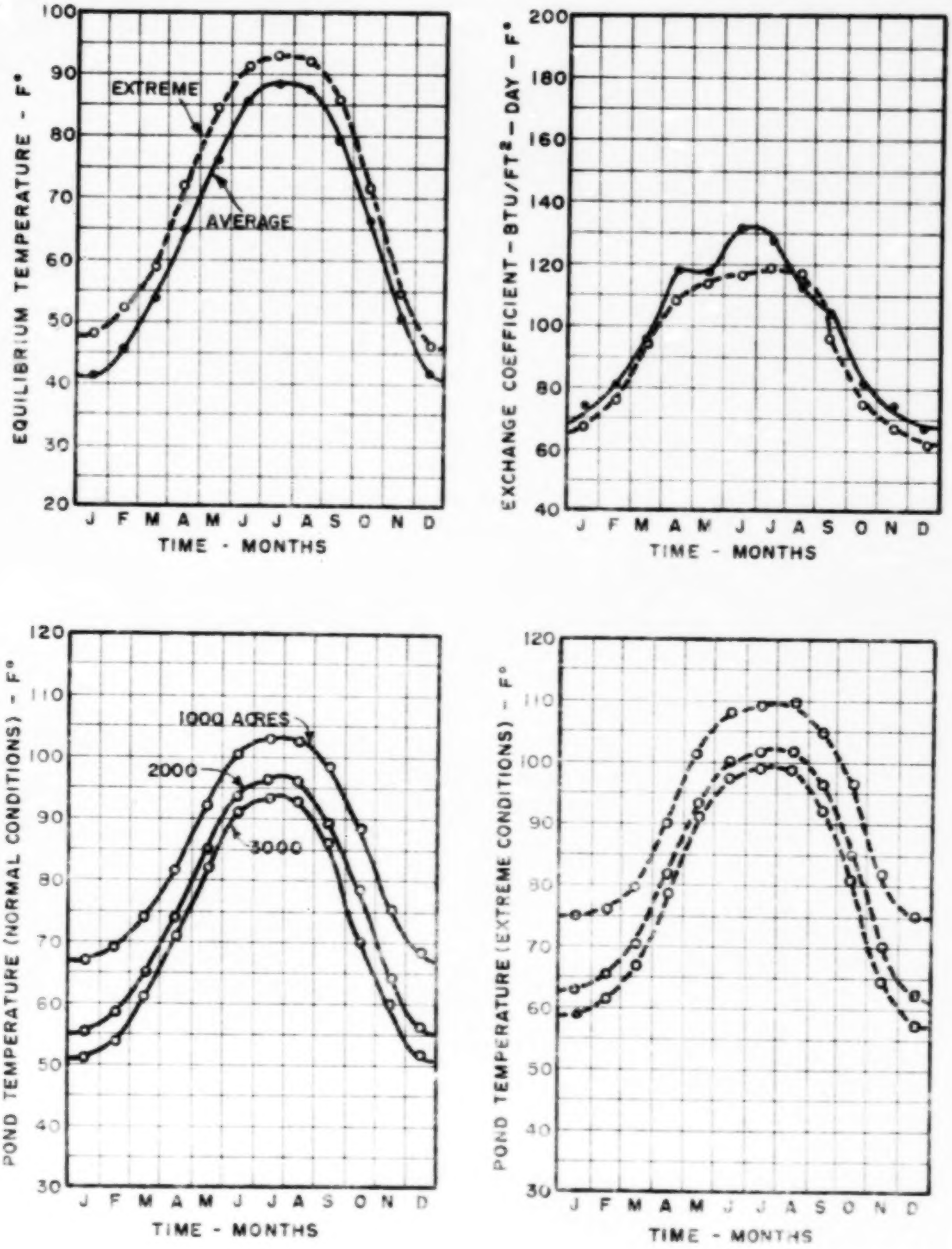

FIGURE 118 - RESULTS FOR KNOXVILLE, TENNESSEE

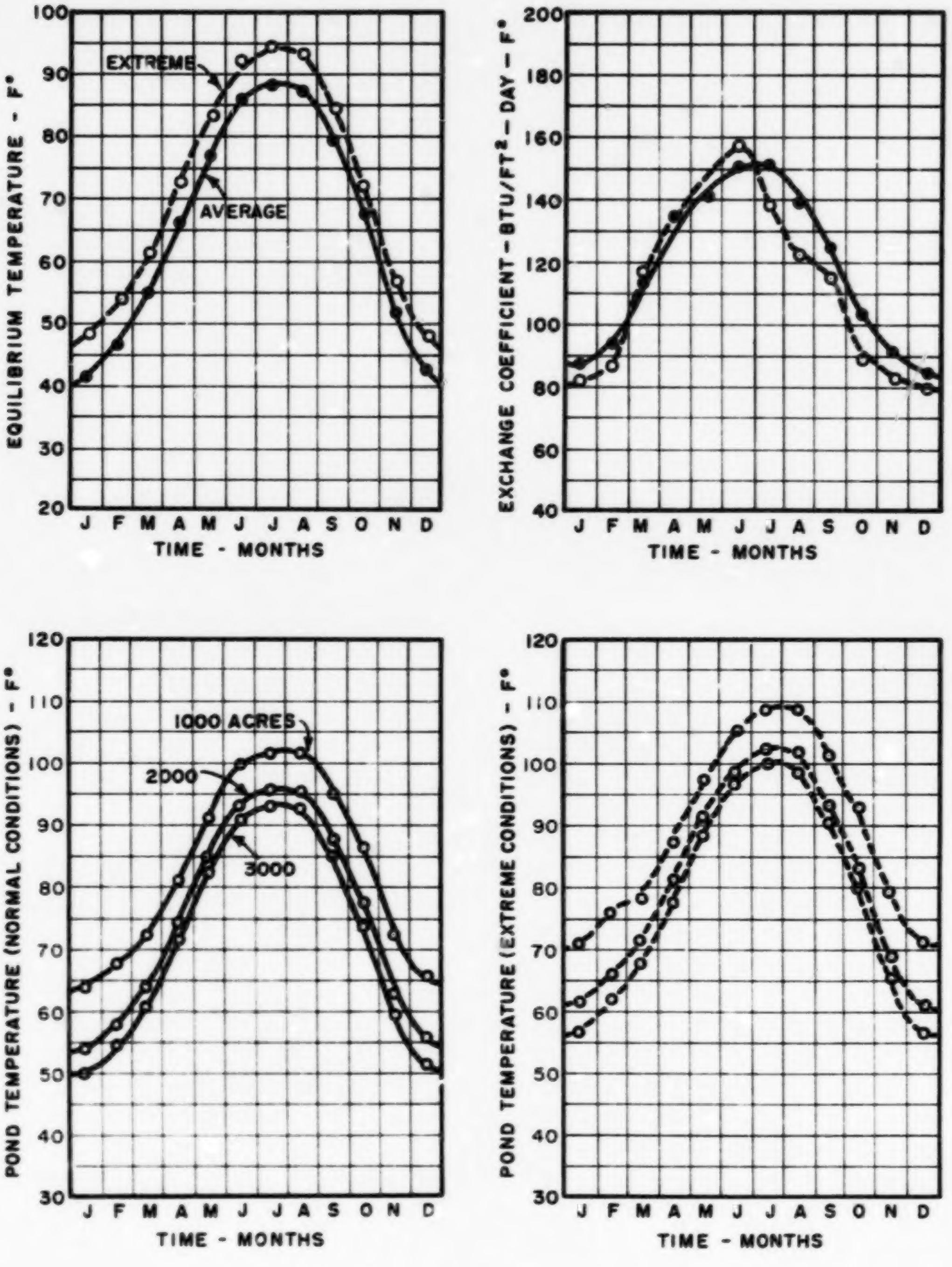

FIGURE 119 - RESULTS FOR MEMPHIS, TENNESSEE

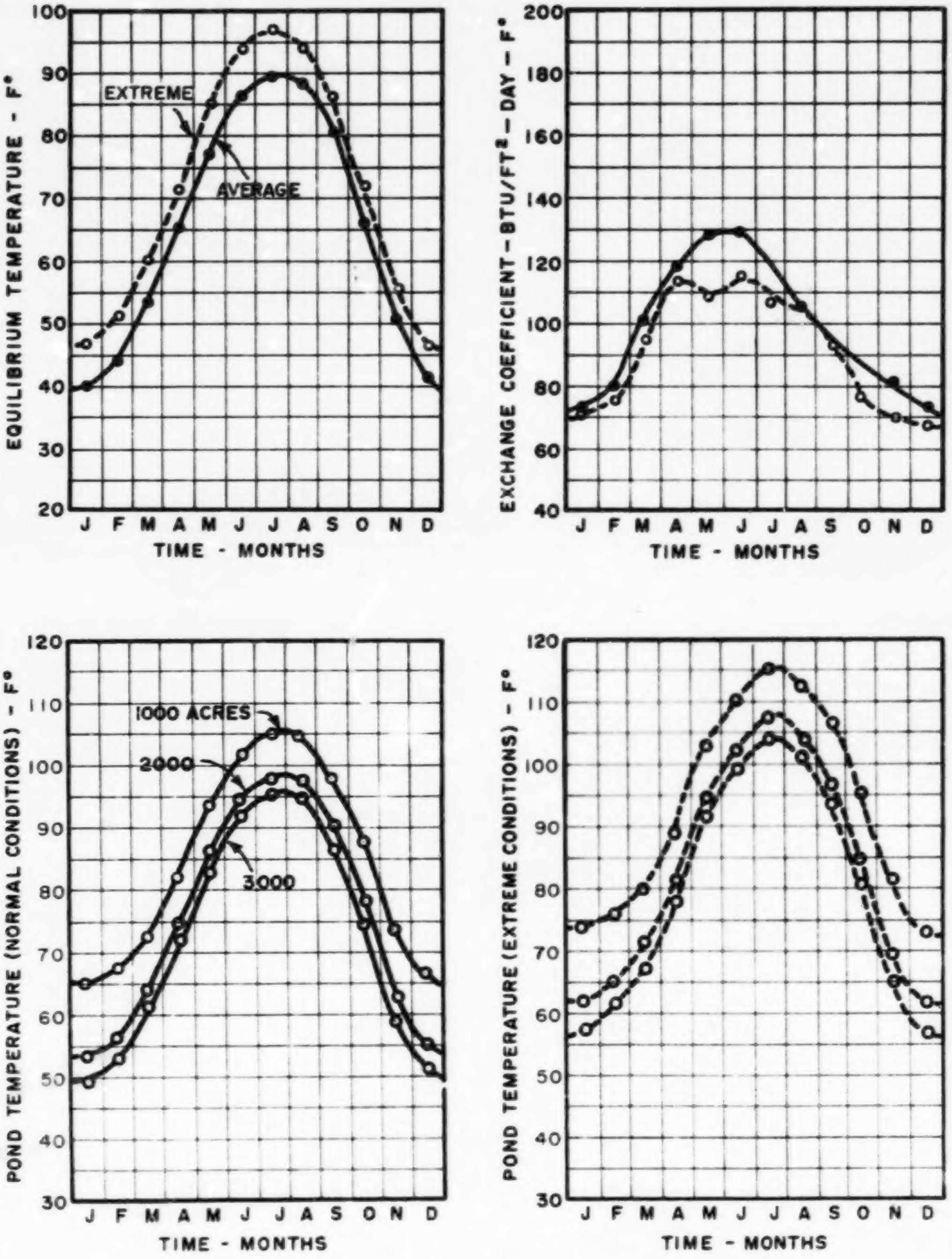

FIGURE 120 - RESULTS FOR NASHVILLE, TENNESSEE

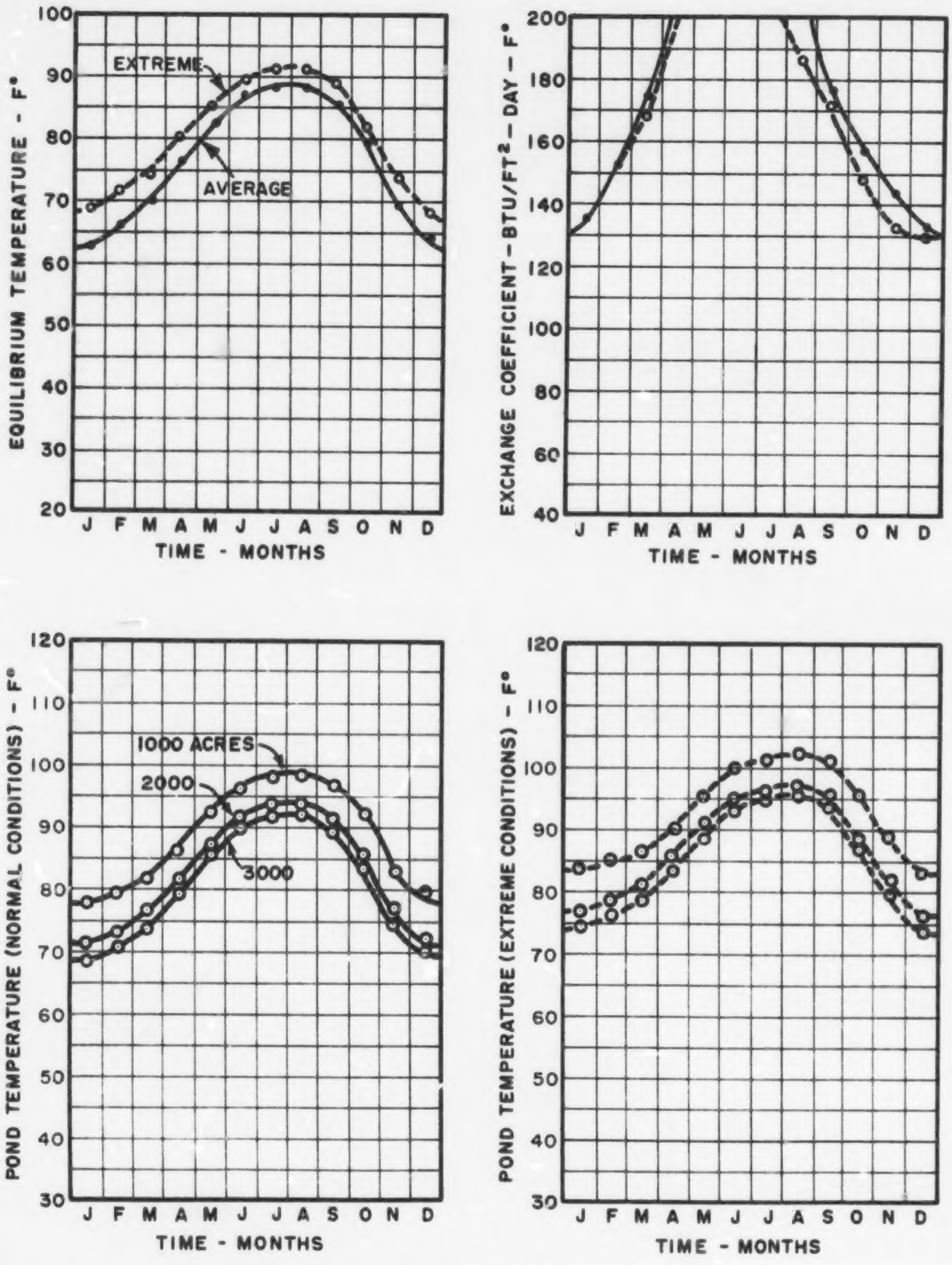

FIGURE 121 - RESULTS FOR BROWNSVILLE, TEXAS

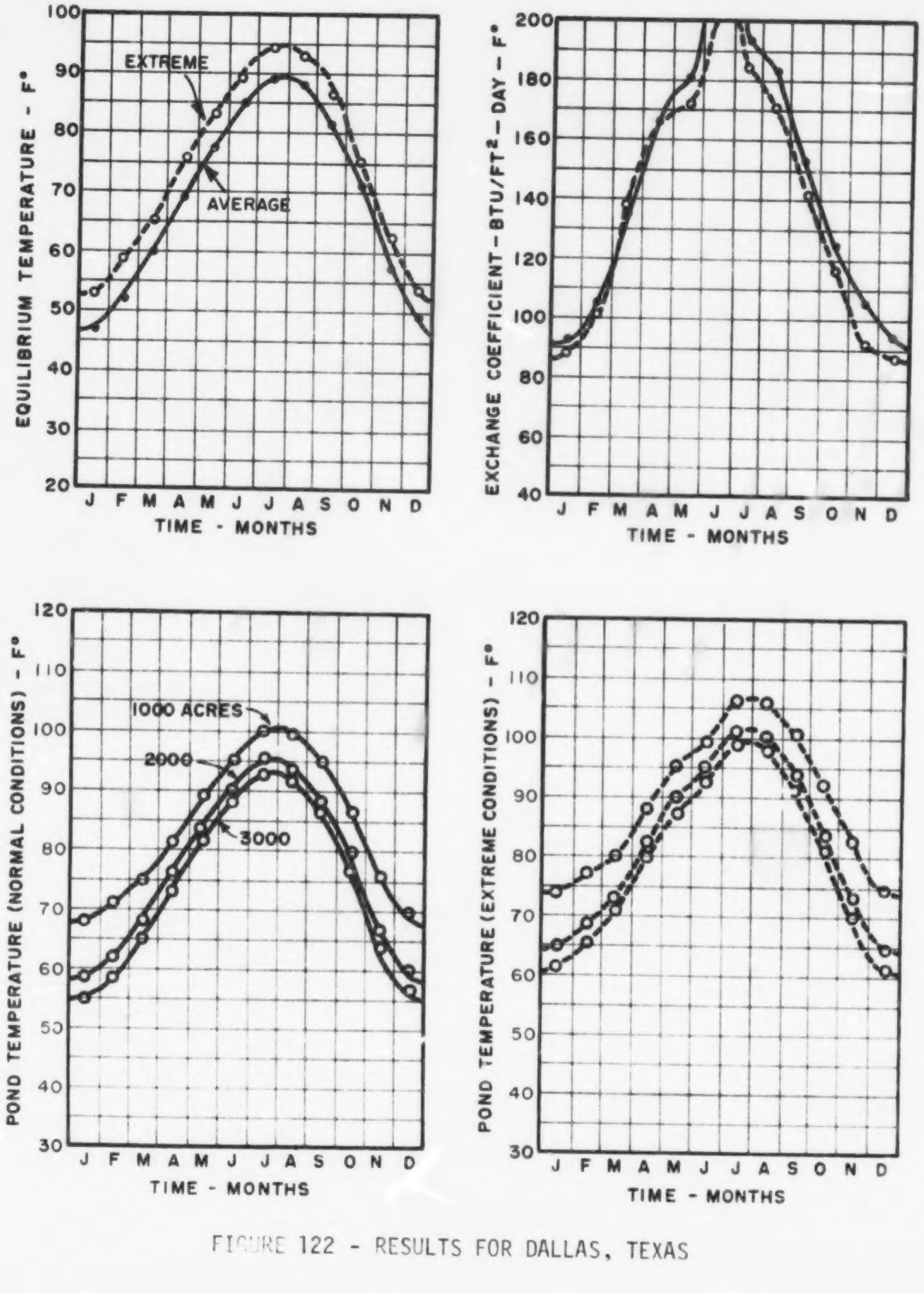

FIGURE 122 - RESULTS FOR DALLAS, TEXAS

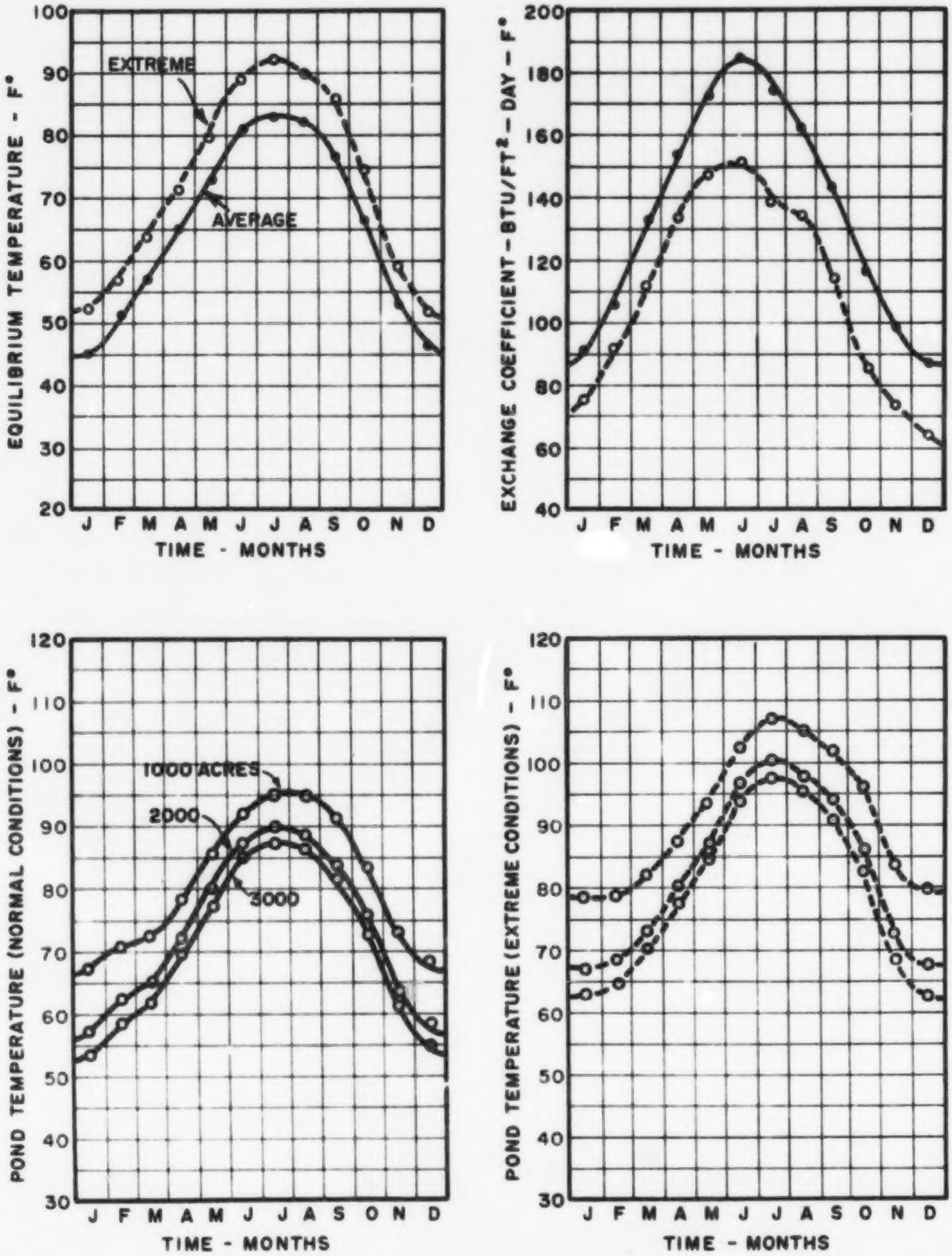

FIGURE 123 - RESULTS FOR EL PASO, TEXAS

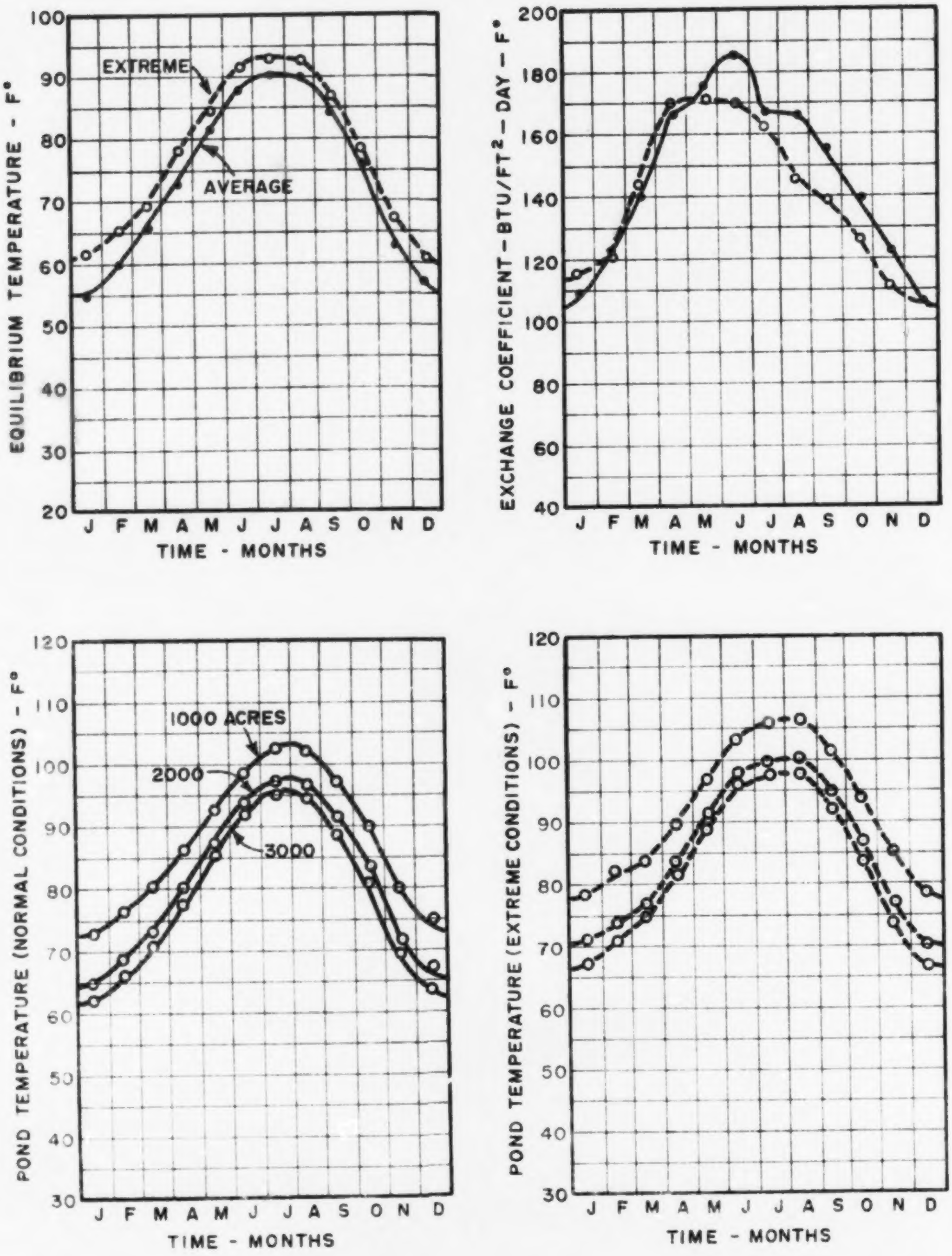

FIGURE 124 - RESULTS FOR HOUSTON, TEXAS

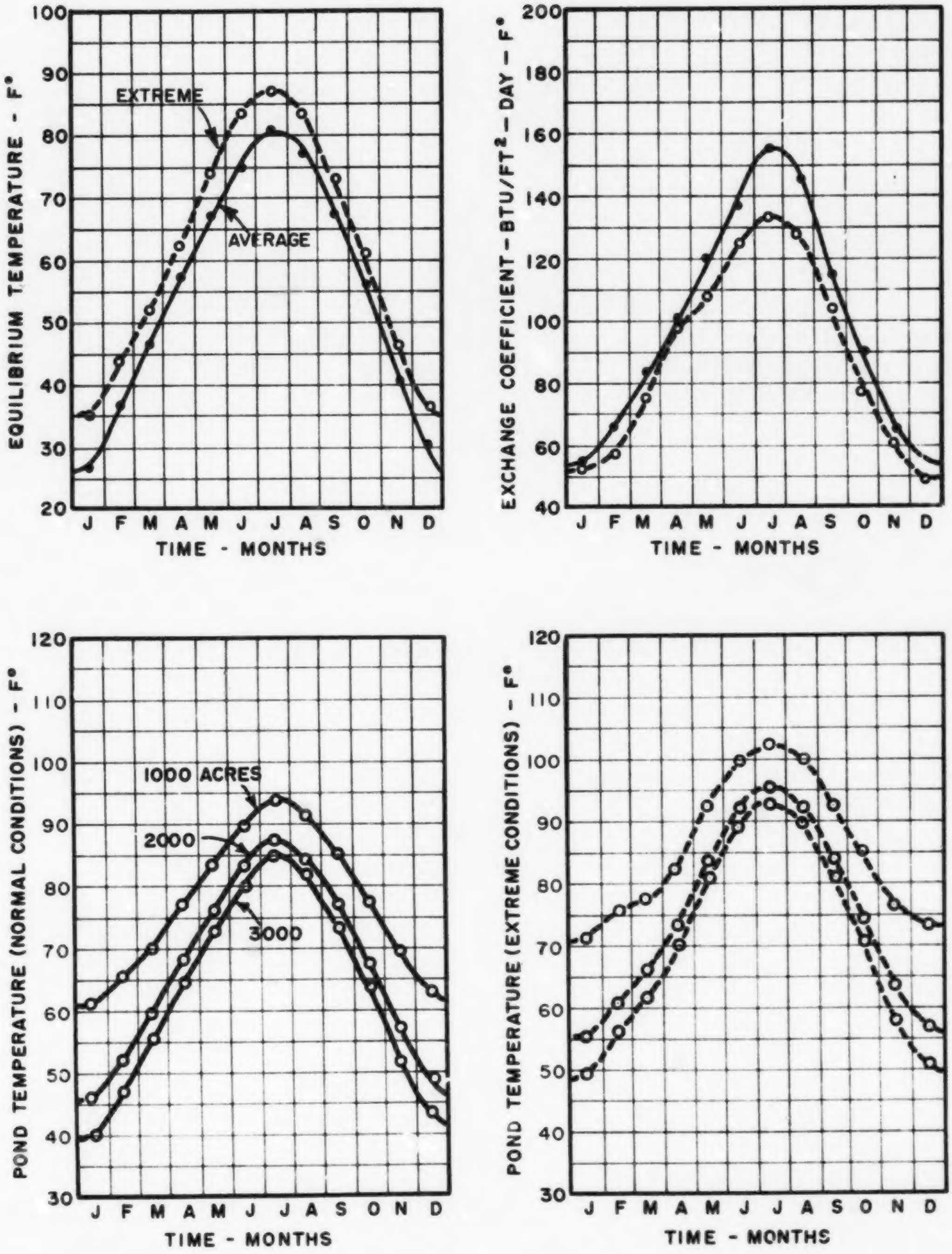

FIGURE 125 - RESULTS FOR SALT LAKE CITY, UTAH

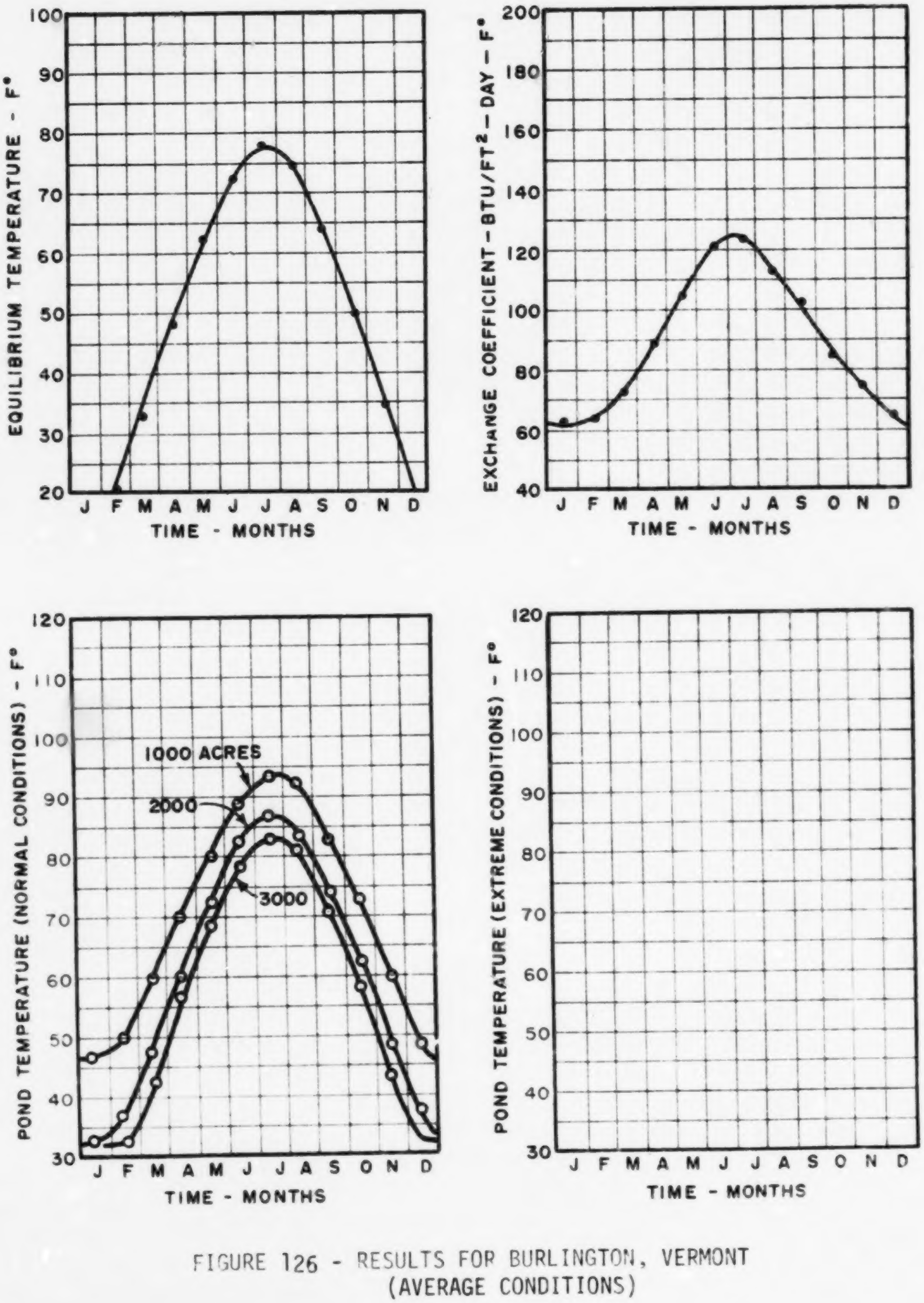

FIGURE 126 - RESULTS FOR BURLINGTON, VERMONT
(AVERAGE CONDITIONS)

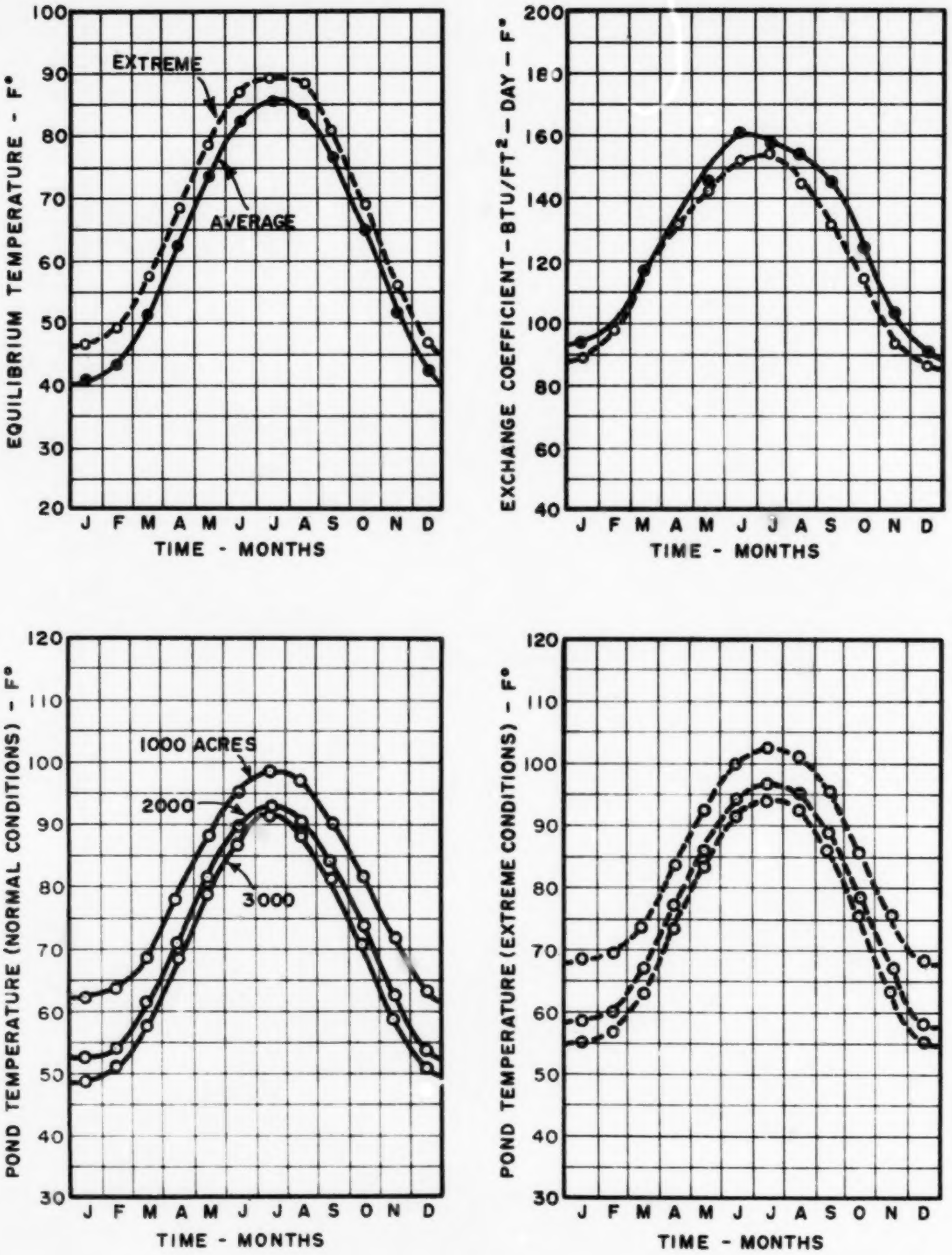

FIGURE 127 - RESULTS FOR NORFOLK, VIRGINIA

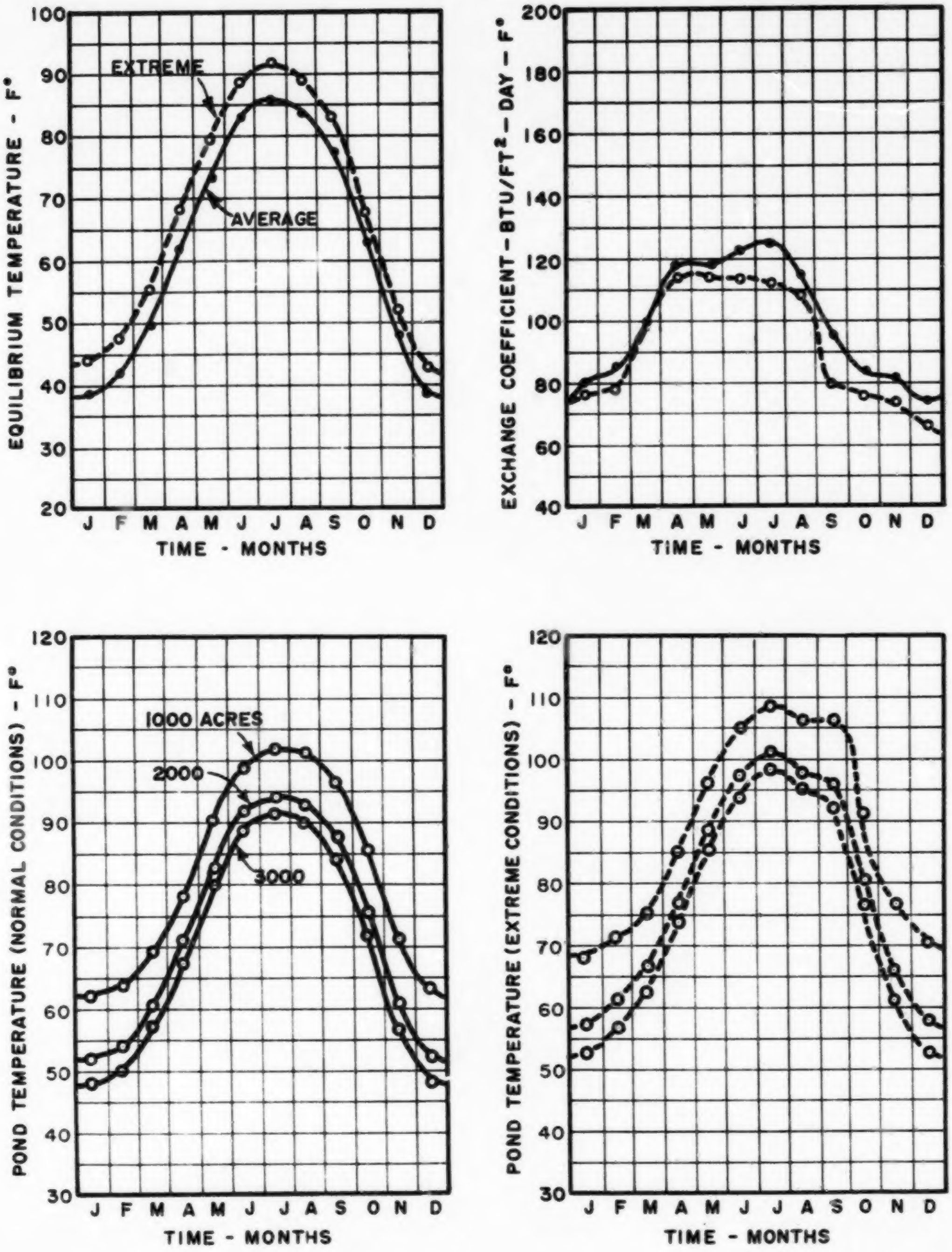

FIGURE 128 - RESULTS FOR ROANOKE, VIRGINIA

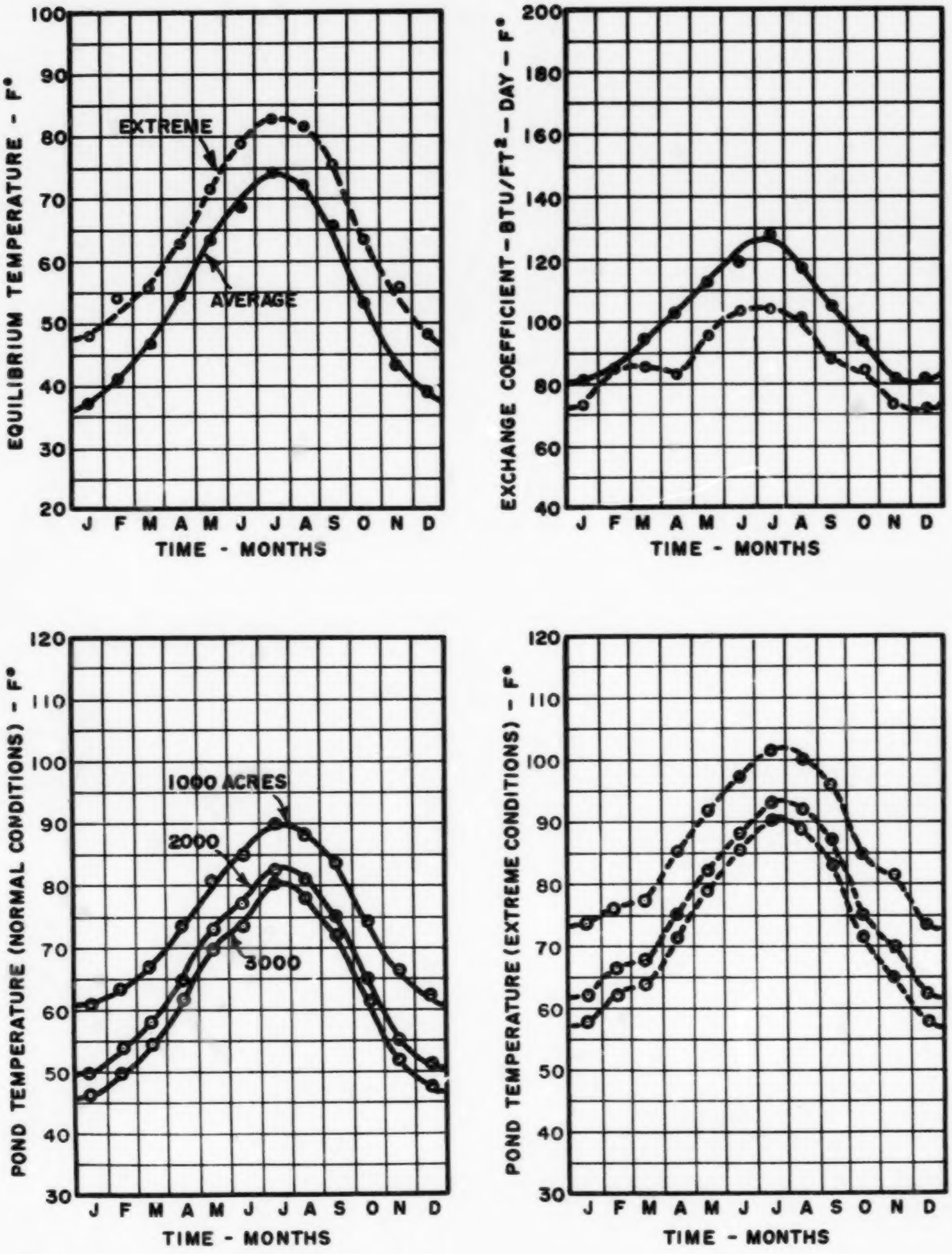

FIGURE 129 - RESULTS FOR SEATTLE, WASHINGTON

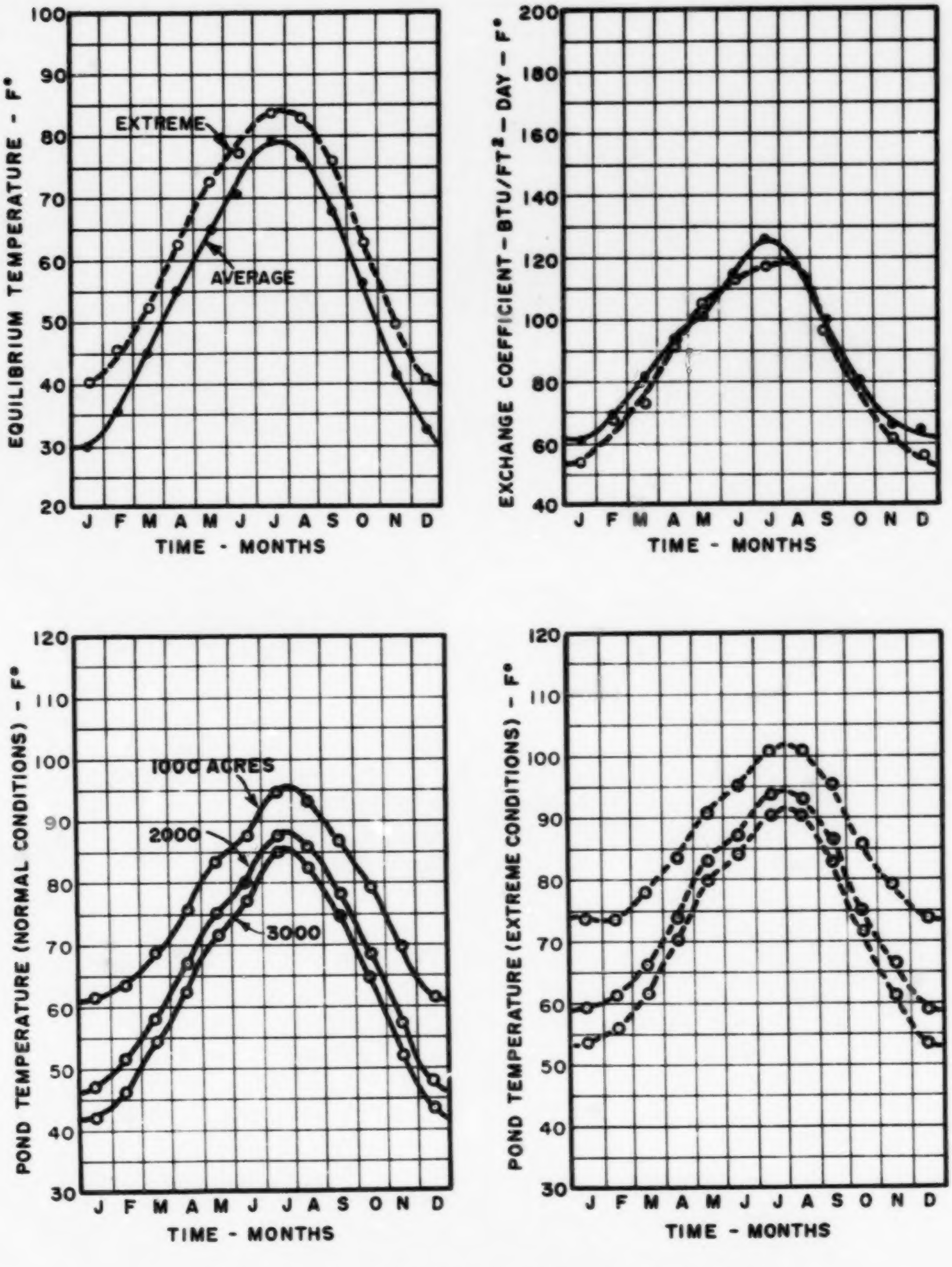

FIGURE 130 - RESULTS FOR SPOKANE, WASHINGTON

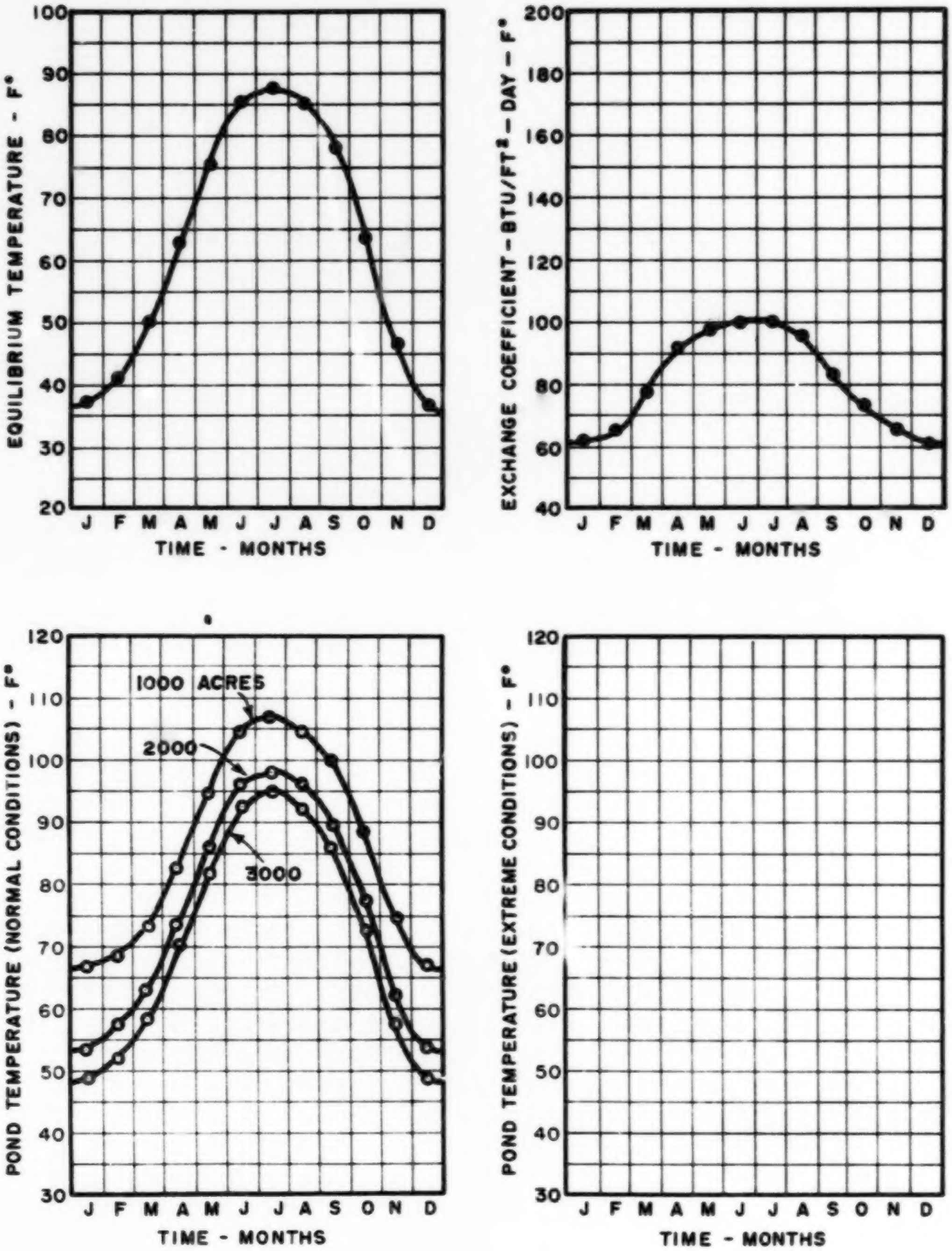

FIGURE 131 - RESULTS FOR HUNTINGTON, WEST VIRGINIA
(AVERAGE CONDITIONS)

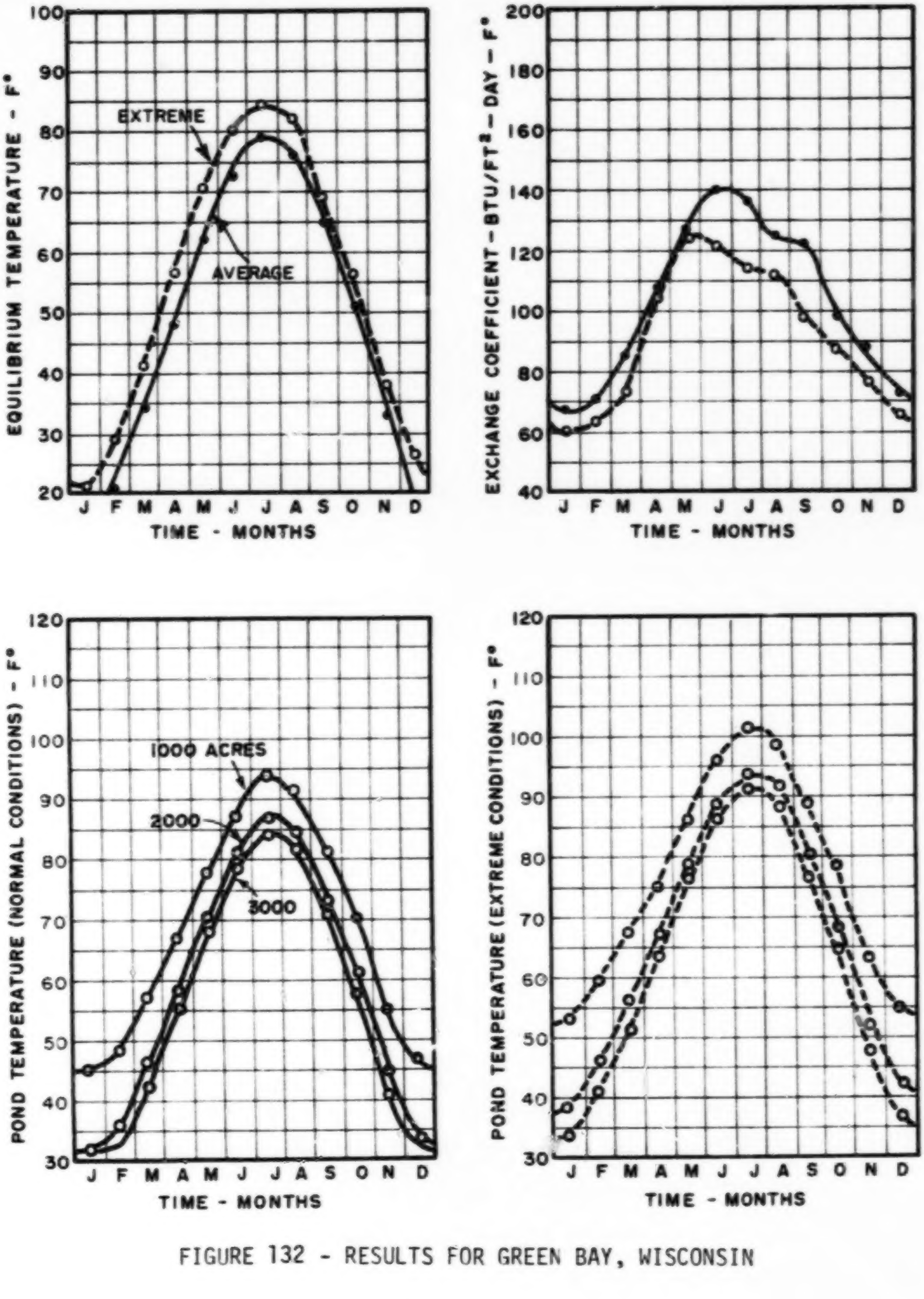

FIGURE 132 - RESULTS FOR GREEN BAY, WISCONSIN

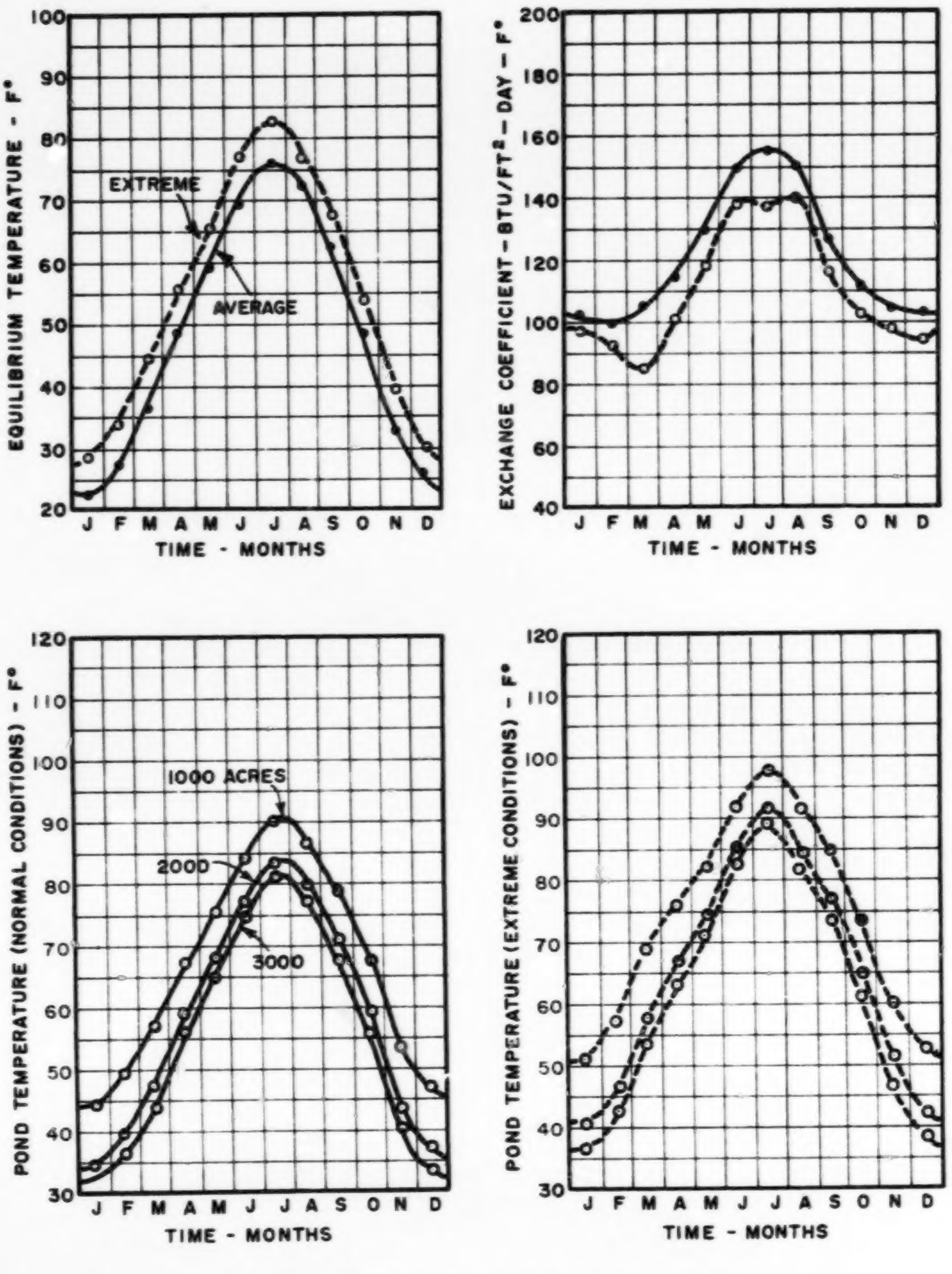

FIGURE 133 - RESULTS FOR CASPER, WYOMING

APPENDIX C

COMPUTER PROGRAM FOR CALCULATING EQUILIBRIUM TEMPERATURES AND HEAT EXCHANGE COEFFICIENTS

```
C     THIS PROGRAM CALCULATES EQUILIBRIUM TEMPERATURES AND EXCHANGE COEFFICIENTS
      REAL LONG,LAT,WETTF
      INTEGER YEAR
      TE=0.
      ALPHA=0.
      H=0.
      DELTA=0.
    1 READ(5,115)R1,R2,R3,R4,R5,R6,R7,R8,R9,R10,R11,R12,R13,R14,R15,R16,
     1R17,R18,R19,R20
  115 FORMAT(20A4)
      WRITE(6,114)
  114 FORMAT('1')
      WRITE(6,100) R1,R2,R3,R4,R5,R6,R7,R8,R9,R10,R11,R12,R13,R14,R15,R1
     16,R17,R18,R19,R20
  100 FORMAT(20A4,//)
    2 READ(5,101) LAT,LONG,ELEV,STA1,STA2,STA3,STA4,STA5,STA6,STA7,STA8,
     1STA9,STA10
  101 FORMAT(3F10.0,10A4)
      IF(LAT) 80,50,8
    8 WRITE(6,107)
  107 FORMAT('1')
      WRITE(6,103) STA1,STA2,STA3,STA4,STA5,STA6,STA7,STA8,STA9,STA10,LA
     1T,LONG,ELEV
  103 FORMAT('LOCATION IS ',10A4,'LATITUDE IS ',F6.2,5X,'LONGITUDE IS ',
     1F6,2,5X,'ELEVATION IS ',F5.0)
    3 READ(5,102) DAY,YEAR,HOUR,CC,TAIR,R,PPT,U,ID1,ID2,ID3,ID4
  102 FORMAT(F5.0,I5,F5.0,2F10.0,F10.2,2F10.0,3A4,A3)
      IF(DAY) 9,2,9
C     ..........................................................................
C     TAIR=TEMPERATURE OF AIR IN DEGREES F
C     R=RELATIVE HUMIDITY AS FRACTION
C     U=WIND SPEED IN MILES PER HOUR
C     CC=CLOUD COVER IN TENTHS OF SKY
C     DAY IS THE DAY OF THE YEAR
C     HOUR IS THE HOUR OF DAY
C     ..........................................................................
    9 WRITE(6,104) DAY,HOUR,YEAR,CC,TAIR,R,PPT,U
  104 FORMAT('DAY = ',F4.0,2X,'HOUR=',F6.3,2X,'YEAR= ',F6.0,2X,'CC=',F4.
     11,2X,'TAIR=',F5,1,2X,'REL HUM =',F3,2,2X,'PPT=',F4,1,2X,'WIND=',F5
     1.1)
      LAT=LAT+0.5
      LAT=INT(LAT)
      IF(HOUR.NE.0.001) GO TO 4
      CALL AVGQI (LAT,QC,DAY)
      GO TO 7
    4 DELTA=-23,28*COS(2,*3,14159*DAY/365,+0.164)
C     H=HOUR ANGLE OF THE SUN
      H=360,*((12,-HOUR)/24,)
      SINAL=(SIN(LAT/57,296)*SIN(DELTA/57,296)+COS(LAT/57,296)*COS(DELTA
     1/57,296)*COS(H/57,296))
      ALPHA=(SINAL)+(SINAL**3)/6+(3*(SINAL**5))/40.+(15.*(SINAL**7))/336.
      ALPHA=ALPHA*57,296
      IF(ALPHA)5,5,6
    5 QC=0
      GO TO 7
    6 QC=(2,044)*ALPHA+(0,1296)*ALPHA**2,-(0.0019)*ALPHA**3,+(0,0000076)
     1*ALPHA**4,0
C     QI IS THE ACTUAL ABSORBED SOLAR RADIATION
    7 QI=QC*(1,-0,0071*CC*CC)
      QI=24,*QI
C     ................................................................
      RATIO=0,655+0,36*R
      WETT=RATIO*TAIR
      EA=EXP(17,62302-9500,826/( ET)+460))
      K=CC
      IF(K) 199,200,199
  199 GO TO (201,202,203,204,205,206,207,208,209,210),K
  200 BETA=(0,15)*EA+0,74
      GO TO 217
  201 BETA=(0,15)*EA+0,75
      GO TO 217
  202 BETA=(0,15)*EA+0,76
      GO TO 217
  203 BETA=(0,143)*EA+0,771
      GO TO 217
  204 BETA=(0,138)*EA+0,763
      GO TO 217
  205 BETA=(0,137)*EA+0,793
      GO TO 217
  206 BETA=(0,135)*EA+0,8
      GO TO 217
  207 BETA=(0,13)*EA+0,81
      GO TO 217
  208 BETA=(0,12)*EA+0,825
      GO TO 217
  209 BETA=(0,105)*EA+0,845
      GO TO 217
  210 BETA=(0,09)*EA+0,866
C     SIGMA IS THE STEFAN-BOLTZMANN RADIATION CONSTANT
  217 SIGMA=0,00000000166
  218 TA4=(TAIR+459,67)**4
      QA=0,97*SIGMA*BETA*TA4
      QA=24,*QA
C     ................................................................
      IF(TE) 13,13,14
   13 TE=110.
   14 CONTINUE
C     QB IS THE EFFECTIVE BACK RADIATION
C     IT IS A FUNCTION OF SIGMA, BETA, AIR TEMPERATURE, AND WATER
C          TEMPERATURE.
  300 TW4=(TE+459,67)**4
  301 QB=-0,97*SIGMA*TW4
      QB=24,*QB
C     ................................................................
C     QE IS THE EVAPORATED HEAT
C     IT IS A FUNCTION OF WIND VELOCITY AND THE DIFFERENCE BETWEEN
C         VAPOR PRESSURE OF SATURATED AIR AND ACTUAL AIR
C     EW IS THE COMPUTED VAPOR PRESSURE OF THE WATER IN SATURATED
C         AIR AT TEMPERATURE OF THE WATER
  108 EW=EXP(17,62302-9500,826/(TE+460))
  400 QE=-13,9*U*(EW-EA)
      QE=24,*QE
C     ................................................................
C     QH IS THE CONDUCTED HEAT BETWEEN WATER-AIR INTERFACE
C      IT IS A FUNCTION OF WIND VELOCITY, BAROMETRIC PRESSURE AND
C        DIFFERENCE BETWEEN TEMPERATURES OF WATER AND AIR
      P=29,92/EXP((32,15*ELEV)/(1543*(TAIR+460.)))
  500 QH=,00843*U*P*(TAIR-TE)
      QH=24,*QH
C     ................................................................
      DELQ=QI+QA+QB+QE+QH
      BETA=(9500,826/(TE+460.)**2)*EXP(17,623-9500,826/(TE+460.))
      EXCO=15,7+(0,01025*BETA)*(333,*U)
      IF(DELQ) 20,30,20
   20 NEWTE=(DELQ+EXCO*TE)/EXCO
      DELTE=NEWTE-TE
      A=ABS(DELTE)
      IF(A.LT.0.1) GO TO 30
      TE=NEWTE
      GO TO 14
   30 WRITE(6,111) TE,EXCO
  111 FORMAT('EQUILIBRIUM TEMPERATURE=',F5.1,' DEGREES F'/1X,'EXCHANGE C
     1OEFFICIENT =',F6.1,' BTU PER SQUARE FOOT PER DAY PER DEGREE F')
   41 WRITE(6,113) QS,QA,QB,QE,QH
  113 FORMAT('SOLAR=',F7.1,2X,'ATM=',F7.1,2X,'BACK=',F8.1,2X,'EVAP=',F8.
     11,2X,'COND=',F7.1,2X,'BTU/SQ FT-DAY-DEGREE F',//)
      GO TO 3
   50 STOP
      END
      SUBROUTINE AVGQI(XSAT,XQI,XDAY)
      LPICK=XSAT-25
      GO TO (961,962,963,964,965,966,967,968,969,970,971,972,973,974,
     1975,976,977,978,979,980,981),LPICK
C     LPICK IS THE LATITUDE MINUS 25--THIS WILL WORK ONLY FOR LATITUDES
C       IN THE RANGE FROM 26-46 DEGREES.  EQUATIONS ARE ARRANGED IN ORDER
C       THE FIRST ONE IS FOR LATITUDE 26, THE SECOND FOR LATITUDE 27,ETC.
  961 XQI=80.155-29.707*SIN(2*3.14159*XDAY/366.+1.679)
      GO TO 982
  962 XQI=79.371-30.236*SIN(2*3.14159*XDAY/366.+1.713)
      GO TO 982
  963 XQI=78.566-31.219*SIN(2*3.14159*XDAY/366.+1.719)
      GO TO 982
  964 XQI=77.604-32.145*SIN(2*3.14159*XDAY/366.+1.740)
      GO TO 982
  965 XQI=76.655-33.156*SIN(2*3.14159*XDAY/366.+1.722)
      GO TO 982
  966 XQI=76.041-34.133*SIN(2*3.14159*XDAY/366.+1.694)
      GO TO 982
  967 XQI=75.060-35.194*SIN(2*3.14159*XDAY/366.+1.737)
      GO TO 982
  968 XQI=74.046-35.938*SIN(2*3.14159*XDAY/366.+1.734)
      GO TO 982
  969 XQI=73.161-36.834*SIN(2*3.14159*XDAY/366.+1.727)
      GO TO 982
  970 XQI=72.248-37.699*SIN(2*3.14159*XDAY/366.+1.733)
      GO TO 982
  971 XQI=71.390-38.598*SIN(2*3.14159*XDAY/366.+1.721)
      GO TO 982
  972 XQI=70.394-39.413*SIN(2*3.14159*XDAY/366.+1.730)
      GO TO 982
  973 XQI=69.350-40.189*SIN(2*3.14159*XDAY/366.+1.741)
      GO TO 982
  974 XQI=68.362-40.982*SIN(2*3.14159*XDAY/366.+1.739)
      GO TO 982
  975 XQI=67.281-41.706*SIN(2*3.14159*XDAY/366.+1.742)
      GO TO 982
  976 XQI=66.240-42.442*SIN(2*3.14159*XDAY/366.+1.736)
      GO TO 982
  977 XQI=65.197-43.128*SIN(2*3.14159*XDAY/366.+1.740)
      GO TO 982
  978 XQI=64.113-43.789*SIN(2*3.14159*XDAY/366.+1.739)
      GO TO 982
  979 XQI=63.010-44.471*SIN(2*3.14159*XDAY/366.+1.737)
      GO TO 982
  980 XQI=61.911-45.020*SIN(2*3.14159*XDAY/366.+1.740)
      GO TO 982
  981 XQI=60.782-45.639*SIN(2*3.14159*XDAY/366.+1.735)
  982 RETURN
      END
```

APPENDIX D

COMPUTER PROGRAM FOR CALCULATING MONTHLY AVERAGE TEMPERATURES FOR LOADED PONDS

```
C      THIS PROGRAM CALCULATES THE TEMPERATURE OF A COOLING POND
C      SUBJECTED TO A CONSTANT HEAT LOAD FROM A POWER PLANT AND
C      CONSTANT WEATHER CONDITIONS
       REAL LAT,LONG
       INTEGER YEAR
       TWAT=48.
        ALPHA=0.
       H=0.
       DELTA=0.
       READ(5,30)R1,R2,R3,R4,R5,R6,R7,R8,R9,R10,R11,R12,R13,R14,R15,R16,R
      117,R18,R19,R20
    30 FORMAT(20A4)
   930 CONTINUE
       READ(5,32) LAT,LONG,ELEV,STA1,STA2,STA3,STA4,STA5,STA6,STA7,STA8,S
      1TA9,STA10
       LWRITE=0
    32 FORMAT(3F10.0,10A4)
       IF(LAT)17,17,940
   940 CONTINUE
       I=0
       READ(5,120) VOL,AREA,FLOW,THETA
C      FLOW IS THE FLOW IN CFS
C      VOL IS THE VOLUME IN ACRE-FEET
C      AREA IS THE SURFACE AREA IN ACRES
   120 FORMAT(4F10.0)
       DEPTH = VOL/AREA
     9 CONTINUE
       H=0
       I=I+1
       READ(5,122)TIN
   122 FORMAT(F10.0)
       IF(TIN.EQ.0.) GO TO 930
        TIN=TIN+15.0
C     ID1,ID2,ID3,ID4 ARE NAMES OF THE FIELDS USED FOR LOCATION
       READ(5,11)DAY,YEAR,HOUR,CC,TAIR,R,RPT,U,ID1,ID2,ID3,ID4
    11 FORMAT(F5.0,I5,F5.0,2F10.0,F10.2,2F10.0,A4,A4,A4,A3)
C      TAIR=TEMPERATURE OF AIR IN DEGREES F
C      R=RELATIVE HUMIDITY AS FRACTION
C      U=WIND SPEED IN MILES PER HOUR
C      CC=CLOUD COVER IN TENTHS OF SKY
C      FLOIN IS THE FLOW RATE OF INCOMING WATER IN CFS
C      TIN IS THE TEMPERATURE OF THE INCOMING WATER IN DEG FAHRENHEIT
C      FLOOUT IS THE FLOW RATE OF OUTGOING WATER IN CFS
C      DAY IS THE DAY OF THE YEAR
C      HOUR IS THE HOUR OF DAY
C      THETA IS THE TIME INCREMENT
       LAT=LAT+0.5
       LAT=INT(LAT)
     5 CONTINUE
       IF(MOD(I,2))17,19,25
    25 WRITE(6,26)
    26 FORMAT('1')
       IF(LWRITE)19,452,19
   452 LWRITE=LWRITE+6
       WRITE(6,31)R1,R2,R3,R4,R5,R6,R7,R8,R9,R10,R11,R12,R13,R14,R15,R16,
      1R17,R18,R19,R20
    31 FORMAT(20A4)
       WRITE(6,39)STA1,STA2,STA3,STA4,STA5,STA6,STA7,STA8,STA9,STA10,LAT,
      1LONG,ELEV
    39 FORMAT('LOCATION IS ',10A4,2X,'LATITUDE IS ',F6.2,2X,'LONGITUDE IS
      1 ',F6.2,2X,'ELEVATION IS ',F5.0)
    19 CONTINUE
    15 WRITE(6,12)DAY,HOUR,YEAR,CC,TAIR,R,RPT,U
   12 FORMAT('DAY =',F5.0,2X,'HOUR=',F6.3,2X,'YEAR=',F5.0,2X,'CC=',F4.1,
     12X,'TAIR=',F5.1,2X,'REL HUM=',F3.2,2X,'PPT=',F4.1,2X,'WIND=',F5.1)
      WRITE(6,121) VOL,AREA,DEPTH,FLOW,THETA,TIN
  121 FORMAT('VOL=',F9.1,' ACRE-FT',4X,'AREA=',F7.1,' ACRES',4X,'DEPTH='
     1,F5.1,' FEET',4X,'FLOW=',F7.1,' CFS',4X,'TIME INC=',F6.2,' HOURS',
     24X,'TEMP IN=',F6.1,' DEG F',/)
      IF(THETA.LT.24.)GO TO 4
      CALL AVGQI(LAT,QC,DAY)
      GO TO 108
    4 DELTA=-23.28*COS(2.*3.14159*DAY/365.+0.164)
C     H=HOUR ANGLE OF THE SUN
      H=360.*((12.-HOUR)/24.)
      SINAL=(SIN(LAT/57.296)*SIN(DELTA/57.296)+COS(LAT/57.296)*COS(DELTA
     1/57.296)*COS(H/57.296))
      ALPHA=(SINAL)+(SINAL**3)/6+(3*(SINAL**5))/40.+(15.*(SINAL**7))/336.
      ALPHA=ALPHA*57.296
      IF(ALPHA)107,107,130
  107 QI=0.0
      GO TO 109
C     QC IS THE CORRECTED SHORT WAVE RADIATION FOR CLEAR SKY
  130 QC=(2.044)*ALPHA+(0.1296)*ALPHA**2.-(0.0019)*ALPHA**3.+(0.000076)
     1*ALPHA**4.0
C     QI IS ACTUAL SOLAR RADIATION
  108 QI=QC*(1.-0.0071*CC*CC)
C     ....................................................................
C     EW IS THE COMPUTED VAPOR PRESSURE OF THE WATER IN SATURATED
C          AIR AT TEMPERATURE OF THE WATER
      RATIO=0.655+0.36*R
      WETT=RATIO*TAIR
      EA=EXP(17.62302-9500.026/(WETT+460.))
  991 CONTINUE
      M=M+1
      IF(M.EQ.50) GO TO 990
  109 EW=EXP(17.62302-9500.026/(TWAT+460.))
      K=CC
      IF(K) 199,200,199
  199 GO TO (201,202,203,204,205,206,207,208,209,210),K
  200 BETA=(0.15)*EA+0.74
      GO TO 217
  201 BETA=(0.15)*EA+0.78
      GO TO 217
  202 BETA=(0.15)*EA+0.76
      GO TO 217
  203 BETA=(0.143)*EA+0.771
      GO TO 217
  204 BETA=(0.138)*EA+0.783
      GO TO 217
  205 BETA=(0.137)*EA+0.793
      GO TO 217
  206 BETA=(0.135)*EA+0.8
      GO TO 217
  207 BETA=(0.13)*EA+0.81
      GO TO 217
  208 BETA=(0.12)*EA+0.825
      GO TO 217
  209 BETA=(0.105)*EA+0.845
      GO TO 217
  210 BETA=(0.09)*EA+0.866
C     SIGMA IS THE STEFAN-BOLTZMANN RADIATION CONSTANT
  217 SIGMA=0.00000000166
  218 TA4=(TAIR+459.67)**4
      QA=0.97*SIGMA*BETA*TA4
C     ....................................................................
C     QB IS THE EFFECTIVE BACK RADIATION
C     IT IS A FUNCTION OF SIGMA, BETA, AIR TEMPERATURE, AND WATER
C          TEMPERATURE.
```

```
  210 TW4=(TWAT+459.67)**4
  220 QB=-0.97*SIGMA*TW4
C
C     ...............................................................
C     QE IS THE EVAPORATED HEAT
C     IT IS A FUNCTION OF WIND VELOCITY AND THE DIFFERENCE BETWEEN
C        VAPOR PRESSURE OF SATURATED AIR AND ACTUAL AIR
  310 QE=-13.9*U*(EW-EA)
C
C     ...............................................................
C     QH IS THE CONDUCTED HEAT BETWEEN WATER-AIR INTERFACE
C      IT IS A FUNCTION OF WIND VELOCITY, BAROMETRIC PRESSURE AND
C        DIFFERENCE BETWEEN TEMPERATURES OF WATER AND AIR
      P=29.92/EXP((32.15*ELEV)/(1545.*(TAIR+460.)))
  400 QH=.00543*U*P*(TAIR-TWAT)
C
C     ...............................................................
C     QT IS THE TOTAL SURFACE HEAT TRANSFER
  500 QT=QI+QB+QE+QH+QA
C
C     ...............................................................
C     SUREN IS THE ENERGY CHANGE DUE TO SURFACE HEAT TRANSFER
  600 SUREN=QT*AREA*THETA/62.5
C
C     ...............................................................
C     ADVEN IS THE ENERGY CHANGE DUE TO ADVECTED WATER
  705 ADVEN=FLOW*THETA*0.06204*(TIN-TWAT)
C
C     ...............................................................
C     TOTEN IS THE TOTAL ENERGY CHANGE
  800 TOTEN=(SUREN+ADVEN)/2.00
C
C     ...............................................................
C     TEMP IS THE TEMPERATURE CHANGE IN DEGREES FARENHEIT
  900 TEMP=TOTEN/VOL
C     TWAT IS THE CALCULATED WATER TEMPERATURE AT THE END OF THIS
C         TIME PERIOD
  950 TWAT=TWAT+TEMP
      TEMPA=ABS(TEMP)
      IF(TEMPA.LE.0.01) GO TO 990
      GO TO 991
  990 CONTINUE
C
C     ...............................................................
      WRITE(6,1000)ALPHA,H,DELTA,EW
 1000 FORMAT('ALPHA=',F10.5,2X,'H=',F10.5,2X,'DELTA=',F10.5,2X,'EW=',F10
     1.5,//)
      QI=24.0*QI
      QA=24.0*QA
      QB=24.0*QB
      QE=24.0*QE
      QH=24.0*QH
      QT=24.0*QT
      WRITE(6,13)QI,QA,QB,QE,QH,QT
   13 FORMAT('SOLAR=',F7.1,2X,'ATM=',F7.1,2X,'BACK=',F8.1,2X,'EVAP=',F8.
     11,2X,'COND=',F7.1,2X,'TOTAL=',F8.1,2X,'BTU/SQ FT-DAY-DEGREE-F',/)
      WRITE(6,16)SUREN
   16 FORMAT('SURFACE HEAT INPUT=',F12.3,2X,'BTU-ACRE-FT PER LBM')
      WRITE(6,27)ADVEN
   27 FORMAT('INFLOW HEAT INPUT(ADVECTED WATER)=',F12.3,2X,'BTU-ACRE-FT
     1LBM')
      WRITE(6,18)TOTEN
   18 FORMAT('TOTAL ENERGY CHANGE=',F12.3,2X,'DEGREES FAHRENHEIT-ACRE-FT
     1',/)
      WRITE (6,20)
   20 FORMAT('THE COMPUTED TEMPERATURE INCREMENT IN DEGREES FARENHEIT IS
     1')
      WRITE(6,21)TEMP
   21 FORMAT(F12.6,/)
      WRITE(6,22)
   22 FORMAT('THEREFORE THE CALCULATED WATER TEMPERATURE IN DEGREES FARE
     1NHEIT IS')
      WRITE(6,23)TWAT
   23 FORMAT(F12.6)
```

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```
      TIME=HOUR+(0.5*THETA)
      WRITE(6,24)TIME
   24 FORMAT('AT HOUR=',F4.1,/////)
      ADRAT=FLOW-FL[illegible]
      VOL=VOL+ADRAT*THETA*.08264
      GO TO 9
   17 CALL EXIT
      END
      SUBROUTINE AVGQI(XSAT,XQI,XDAY)
      LPICK=XSAT-25
      GO TO (961,962,963,964,965,966,967,968,969,970,971,972,973,974,
     1975,976,977,978,979,980,981),LPICK
C     LPICK IS THE LATITUDE MINUS 25--THIS WILL WORK ONLY FOR LATITUDES
C        IN THE RANGE FROM 26-46 DEGREES.  EQUATIONS ARE ARRANGED IN ORDER
C        THE FIRST ONE IS FOR LATITUDE 26, THE SECOND FOR LATITUDE 27,ETC.
  961 XQI=80.155-29.207*SIN(2*3.14159*XDAY/366.+1.679)
      GO TO 982
  962 XQI=79.371-30.236*SIN(2*3.14159*XDAY/366.+1.713)
      GO TO 982
  963 XQI=78.566-31.219*SIN(2*3.14159*XDAY/366.+1.710)
      GO TO 982
  964 XQI=77.604-32.145*SIN(2*3.14159*XDAY/366.+1.740)
      GO TO 982
  965 XQI=76.655-33.156*SIN(2*3.14159*XDAY/366.+1.728)
      GO TO 982
  966 XQI=76.041-34.133*SIN(2*3.14159*XDAY/366.+1.694)
      GO TO 982
  967 XQI=75.060-35.194*SIN(2*3.14159*XDAY/366.+1.737)
      GO TO 982
  968 XQI=74.046-35.938*SIN(2*3.14159*XDAY/366.+1.734)
      GO TO 982
  969 XQI=73.161-36.634*SIN(2*3.14159*XDAY/366.+1.727)
      GO TO 982
  970 XQI=72.248-37.699*SIN(2*3.14159*XDAY/366.+1.739)
      GO TO 982
  971 XQI=71.390-38.598*SIN(2*3.14159*XDAY/366.+1.721)
      GO TO 982
  972 XQI=70.394-39.413*SIN(2*3.14159*XDAY/366.+1.730)
      GO TO 982
  973 XQI=69.350-40.188*SIN(2*3.14159*XDAY/366.+1.741)
      GO TO 982
  974 XQI=68.362-40.982*SIN(2*3.14159*XDAY/366.+1.739)
      GO TO 982
  975 XQI=67.281-41.706*SIN(2*3.14159*XDAY/366.+1.742)
      GO TO 982
  976 XQI=66.240-42.442*SIN(2*3.14159*XDAY/366.+1.736)
      GO TO 982
  977 XQI=65.197-43.128*SIN(2*3.14159*XDAY/366.+1.740)
      GO TO 982
  978 XQI=64.113-43.788*SIN(2*3.14159*XDAY/366.+1.739)
      GO TO 982
  979 XQI=63.010-44.471*SIN(2*3.14159*XDAY/366.+1.730)
      GO TO 982
  980 XQI=61.911-45.020*SIN(2*3.14159*XDAY/366.+1.740)
      GO TO 982
  981 XQI=60.782-45.639*SIN(2*3.14159*XDAY/366.+1.735)
  982 RETURN
      END
```